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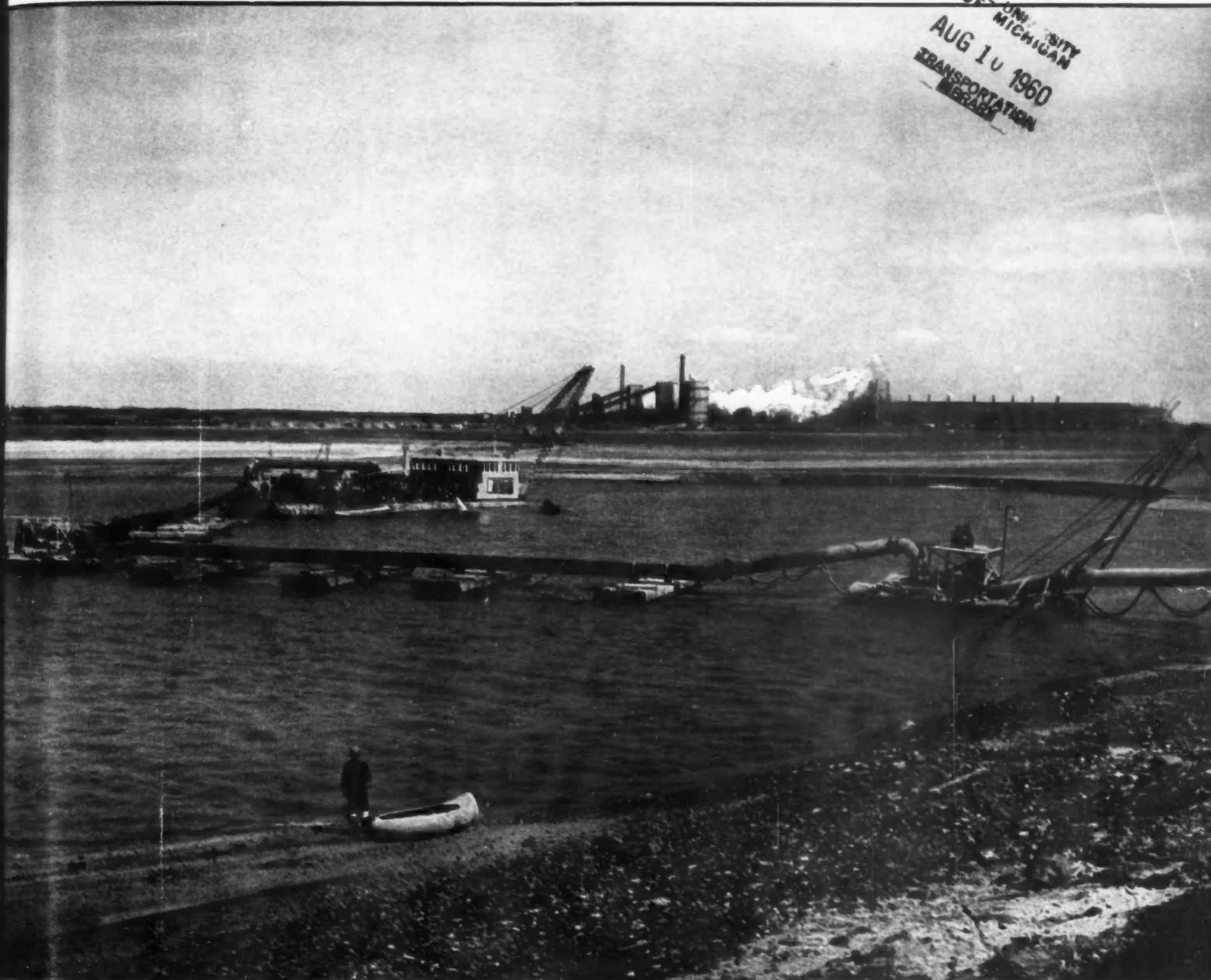

Reclamation for extension of Steel Mills for John Summers & Sons Ltd.

The Dock & Harbour Authority

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Editorial Notes

Transit and Storage Sheds in the Port of London

In the descriptions of modern port developments in many different parts of the world which we have published during recent months, several noteworthy designs of wide-span transit sheds have been featured, that at Los Angeles being perhaps the superlative example of solid-web portal construction. The provision of 100,000 square feet of unobstructed floor area per berth, with a clear span of 200-ft., must not of course be taken as the archetype or pattern for adoption everywhere. Indeed, with the voyage itineraries of cargo liners taking on some of the characteristics of a milk round, it would appear that the scope for such grandiose facilities must be confined to what are indisputably "base" ports. But, despite this, several factors have contributed to the need for more elbow room in modern sheds. First and foremost, fork trucks, now almost universally employed, require floor space virtually unobstructed by columns if they are to be used to the best effect and this, in turn, has put multi-storey sheds very much out of favour. Secondly, the fork truck has only to be used for it to reveal its inherent limitations—in lifting cargo it is not always the next package which is wanted, but the next but one, a difficulty which the more costly swivelling gallows truck only partially overcomes—so that mobile cranes are pressed into service which require wider alleyways and slewing space and more headroom over piled cargo. Smaller consignments of more variegated general cargo, which seem to have become the rule, require additional alleyways for access and although palletised cargo ought to allow "air rights" to be utilised, it is quite surprising how seldom they are. Pallets themselves "bulk" cargoes very considerably and they introduce a storage and transport problem on their own account.

All-in-all, therefore, the more commodious sheds of today do not generally yield proportionately more useful space but, on balance, the new methods of working have so many advantages that the higher cost of shed construction is a small price to pay for them. A wide-span shed undoubtedly allows a high degree of flexibility in working which has its great appeal to traffic managers, but it is as well for them to realise that as compared with a span of 130-ft. (which might be looked on as a reasonable maximum) a 200-ft. span incurs a cost penalty of something like 40 per cent with equal floor coverage.

It is somewhat surprising, however, that in view of the revolutionary changes which have taken place in cargo handling since the war, the maximum clear span of the Port of London sheds should have remained at 65-ft. until 1956. This is revealed in an article we publish in this issue, which provides a most instructive account of five new types of shed having clear spans ranging between 110-ft. and 200-ft. (in the last case, less the depth of internal lattice stanchions) which the Authority has lately constructed. These comprise umbrella, latttice truss and tied-arch types and they are of especial interest in that in all cases the truss members are of tubular form. Previous experience with non-conventional forms has been that the saving in material is not accompanied by a corresponding reduction in cost unless the fabrication embraces good repetition and simplicity of detail but it would now appear in the examples given, that clean and simple design of tubular construction can be strictly competitive with orthodox practice. Modern building construction offers many alternative forms which may be used to satisfy the functional requirement of any given structural problem, most of which are competitive in cost when used to the best advantage, but become uneconomic when used in an inappropriate manner. Selection may be further complicated by fluctuations in the availability of the materials. The paper we publish provides an illuminating commentary on these aspects of design.

The criterion of shed design must of course be fitness for purpose, and where operational requirements are so diverse we must expect an almost infinite variety in space standards. Transit sheds must obviously not be used as long-term repositories for cargo and they are more usefully employed in conjunction with separate storage space close at hand to accommodate left-overs. The whole subject of cargo movement is still permeated by conventional thinking, however, which frequently perpetuates irrational practices. Why, for example, are ultra-wide span sheds provided with loading platforms throughout their length totally unprotected from the weather? What advantage is there in loading platforms at all when they impede the use of fork trucks in attending vehicles? The very wide sheds now in service are commonly operated with a broad thoroughfare for vehicles down the middle and it would seem that there might be overriding advantages for facilitating movements by having flush floors throughout. Is it entirely necessary to provide covered storage for all cargo in transit when much of it can be safely accommodated in the open air? In particular, to do this with container traffic requiring "high boys" for its transport seems to be the height of absurdity, but in other directions it must be conceded that the packaging experts have done their job so well that merchandise which otherwise would take no harm out of doors has often to be given shed storage for fear of spoiling its attractive exterior.

New Simplified Form of Passenger Manifest

A matter of some encouragement to those who are endeavouring to reduce the volume of paper work in the shipping and port industries is the recent announcement that, after discussions and negotiations over a period of years, the U.K. Government through the Ministry of Transport has agreed to the introduction of a simplified manifest for passengers travelling by sea. It is expected that the new form will be introduced in the near future—possibly the early autumn—and will be limited to a simple nominal roll instead of the present elaborate manifest consisting of no less than 13 columns. It will provide information, such as name, nationality, class of travel and destination of the passenger, and should reduce the work of the travel agents because there will be no need to obtain certain information at the time of booking. The passenger will provide the information which he can fill in during the voyage instead of the owner or agent obtaining it beforehand.

Unfortunately, however, the form will still have to be despatched to a Government department, whereas air lines are not required to do so. It is difficult to understand why this differentiation should still be made.

The Problem of Siltation at the Port of Calcutta

According to recent reports in the Indian Press, considerable anxiety is being caused by the rapid and progressive deterioration of the River Hooghly and the danger that this constitutes to the Port of Calcutta, which is India's largest port and handles about half the total seaborne traffic of the country. The port is situated 126 miles inland on the bank of the Hooghly a comparatively narrow river which forms the western leg of the Ganges Delta. In such conditions the configuration of the channel is highly unpredictable (as the formation of the Delta itself must bear witness) and calls more and more on man's endeavours to keep it navigable throughout the year.

The position is complicated by the fact that for eight or nine months of the year the river is virtually a tidal inlet obtaining significant head water supplies for only about four months during which period the freshet discharges from the feeder rivers are heavily charged with silt. Furthermore, the river being tidal, the flood tide transports bed material upstream for the reason that it is of shorter duration than the ebb and has correspondingly greater velocity and consequent scouring effect. A characteristic of deltaic conditions is that flow upstream in the flood channel is relatively straight, because the flood tide is generated by the energy of the high-velocity tidal wave, whereas the ebb tide has none of the qualities of a wave and is, in fact, a subcritical flow. due to gravity. The gradual deterioration of navigation channels is inescapable in these conditions and dredging and other remedial works must necessarily be an increasing and continuing liability. The situation appears to have been aggravated in recent years because of the diminution of upstream water supply, but whether this is indication of cyclic climatic changes alone, or whether large scale abstractions for irrigation or industrial purposes have played a part, has not been specified. These questions are assuming importance in other countries and point to the need for adequate overall conservancy control of riparian development where major waterways are involved.

The deteriorating conditions in the Hooghly are causing grave concern equally to the Government of India and to shipping interests for they have resulted in severe cuts in permissible drafts. The effect that this has had on the utility of the Port will be shewn by the fact that for the majority of liners calling at Calcutta there were 15 days in January 1957 when they could sail with a draft of 24-ft. or more, whereas during January 1959 there was only one such day. Maximum outward drafts have fallen from 27-ft. during January 1957 to 24-ft. in 1959 and maximum inward drafts have been reduced by the same margin. This reduction represents about 2,000 tons of cargo for average ocean vessels which, added to the fact that a draft of 27-ft. is at least 3-ft. less than a modern cargo liner's full draft, results in a total loss of carrying capacity of something like one-third of an average liner's full capacity. It has been suggested that the true position is somewhat obscured by the current trade recession for, had trade been as heavy in the last 12 months as in recent years, the greater number of ships required for both imports and exports, because of draft limitations, would inevitably have caused severe congestion of ships.

Apart from the loss to shipping interests, all these factors may have serious consequences on the country's economy and external balance of payments position. If shipping is to continue facing a limited capacity into and out of Calcutta, freight rates would need to be adjusted which would have a double effect in increasing the cost of India's exports overseas. It is in this context that Government's decision to open an anchorage at Haldia, below Balari Bar, assumes significance. At present there are no facilities and the proposal is to use it as an anchorage during the fair weather period from November to February for the purpose of lightening food ships before they proceed upstream.

International Association of Great Lakes' Ports

A 2-day meeting was held in Toronto last month to discuss the establishment of an association of Great Lakes' ports. Executives from nine U.S. and three Canadian ports were present, representing the ports of Buffalo, Cleveland, Duluth, Green Bay, Kenosha, Milwaukee, Muskegon, Ogdensburg, Rochester and Toledo in the United States and Hamilton, Lakehead (Fort William/Port Arthur) and Toronto in Canada. The ports of Chicago, Detroit, Erie and Waukegan expressed interest in the new association but were not represented.

During the meeting, a constitution was agreed and it was decided that all ports on the Great Lakes would be eligible for membership and that an inaugural meeting would be held in Montreal to coincide with the annual meeting of the American Association of Port Authorities on September 18, 1960. The association will be in two sections dealing with all matters of mutual interest as a joint group but, where purely Canadian or U.S. matters are concerned, acting independently. Annual meetings will be held alternately in an American or Canadian port.

Several committees were established. One, to be known as the Traffic Committee, will study rail, road and shipping costs and practices; another, on Law and Legislature, will study all Canadian and U.S. legislature affecting the economics of the area. Port charges, working methods and labour problems will be a matter for special study and will be discussed at an early date.

Concern was expressed at the increasing contamination of water by industrial effluents. A report was made on the work being carried out by the International Joint Commission and the U.S. Health and Agricultural Departments in studying this problem, and it was agreed that each port should watch the situation closely and that a paper should be presented at the next meeting reviewing the position.

Development of the Smaller Canadian Ports

Another announcement of interest concerns the decision of the Canadian Federal Government to promote trade at the smaller Canadian ports by granting monetary aid to assist their development. It is understood that twenty-nine ports have already been surveyed by an investigating committee from the Department of Transport and Public Works, and that further surveys will be undertaken for any port requesting it. Apparently, the limit of the grant for harbour development has not yet been determined, but this new plan should ensure the improvement of those ports most likely to benefit.

Some Recent Sheds in the Port of London

Economy of Wide-Span Designs

By E. NEWTON, B.Sc.(Eng.), A.M.I.C.E.

Synopsis

In recent years there has been a marked trend in the Port of London towards larger spans in single-storey transit and storage sheds. The increasing use of mechanical handling equipment demands larger floor areas clear of internal columns than those customarily provided in the past, as well as greater internal height and larger door openings. The main engineering problems posed in the design of the five sheds described below, with spans varying from 110-ft. to 200-ft., have been in the selection of the most suitable structural shape and medium to minimise the additional weight and cost of the framework of the sheds and to balance it as far as possible against reduced drainage and foundation costs. Full use has been made of welded steel construction, including a high proportion of tubular steelwork, to achieve economic solutions.

Introduction

Prior to 1956 the largest roof span between columns of any of the Port of London Authority's single-storey sheds was 65-ft. Between 1956 and 1960 five sheds were constructed (Table 2), with spans varying from 110-ft. to 200-ft., providing a total of 400,000 sq. ft. of covered accommodation. Four of the sheds are single span, with the roof span equal to the full width of the shed, thus leaving the shed clear of any internal columns.

The main reason for this trend has been the gradual revolution in cargo handling methods between quay, shed and goods vehicle brought about by the ubiquitous forklift truck, the pallet and, in the case of certain types of cargo such as timber, linerboard, hardboard, etc., the mobile crane. Internal columns, together with the vulnerable rainwater pipes frequently attached to them, not only take up valuable space inside the shed but can represent both a hazard and an obstacle to mechanised shed working. In at least one case—the new shed at No. 4 Berth, Royal Victoria Dock—the shipping line using the shed proposes to introduce container traffic, and this type of traffic may well become more generally established. Containers measuring 16-ft. x 8-ft. x 7-ft. clearly require the maximum of unobstructed floor space which it is economically possible to provide.

" Economicaly possible "—this was the task of the designers, for whilst there was undoubtedly an advantage in getting rid of the internal columns, it nearly always meant a doubling of the roof span to the full width of the shed, thus making the conventional steel roof truss an uneconomic proposition. If this increase in span could be achieved at litle or no additional *overall* cost for the complete shed, this would provide a strong stimulus for a change in planning policy.

Structural shape and medium

General

Design studies for larger roof spans, undertaken by the engineering department of the Authority between 1956 and 1958, produced a number of roof designs which were both light and economical, and yet complied with the requirements of the relevant building codes and standards—in particular B.S.449 " The use of Structural Steel in Building ".

The design studies indicated that, for the larger spans and heights contemplated, welded lattice steel structures provided with ties at column cap level showed greater promise of economy than the, admittedly, more elegant portals. For a " pin-pointed " lattice roof structure consisting by its nature of members subjected to tension and compression only—as distinct from bending and shear—it has long been known that tubes, by virtue of their shape, lesser permissible minimum thickness and size, absence of " outstanding legs " and of holes for fastenings, can have an economic advantage over rolled steel sections such as angles, channels, etc. The practical application of this knowledge, however, had to await the development of the requisite welding and fabrication techniques for tubes.

Welded tubular fabrication

Considerable strides in the fabrication of welded tubular steel lattice structures have been made since the war in the U.K., France, Germany, Italy and Czechoslovakia, though strangely, little appears to have been done in the United States. The main impetus has come from the manufacturers of steel tubes who were, naturally enough, anxious to see tubes take their place as structural members alongside the old-established rolled sections. As the latter are, however, produced by other steelmakers using different processes, the task had to be tackled by the tube-manufacturers themselves or by their subsidiary companies. On the continent, Mannesmann and Phoenix-Rheinrohr in Germany, Dalmine in Italy and Vallourec in France have all played their part, whilst in the U.K. the techniques of welded tubular fabrication have been developed to a considerable degree of efficiency by Tubewrights Ltd., a subsidiary of Stewarts and Lloyd Ltd. Today, welded tubular steelwork is accepted as a useful product of the structural steelwork industry and its basic design and fabrication are covered in the latest revision (1959) of B.S.449.

The reduction in weight which can be achieved by welded tubular lattice roof construction is of the order of 30-40% compared with bolted or rivetted rolled steel (i.e. mainly angle) construction, and 10-20% compared with welded rolled steel. Table 1 gives approximate current prices (ex mill) for mild steel tubes (Grade 16, B.S. 1775) and rolled steel sections (B.S. 15) in the U.K.—

Table 1

COST PER TON

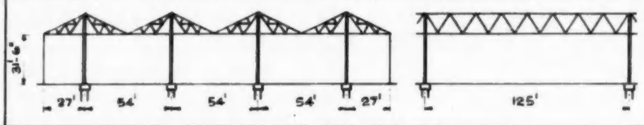
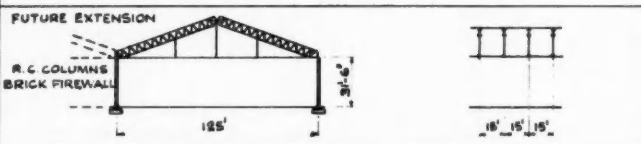
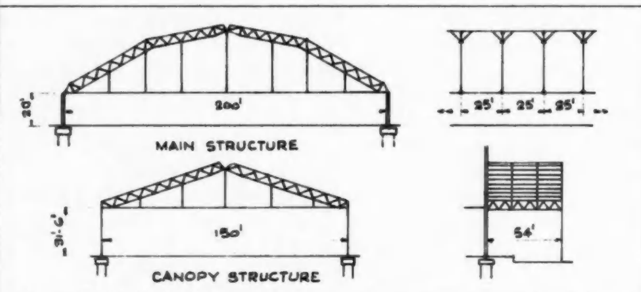
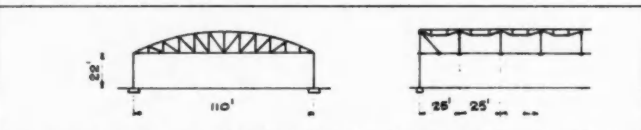
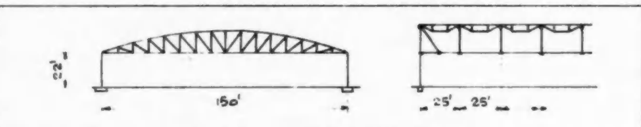
Tubes		Rolled Steel Sections
Up to 4½-in. O.D. (Continuous weld process of manufacture)	Over 4½-in. O.D. (Hot finished seamless process)	
£50-£55	£70-£75	£40-£45

For tubes up to and including 4½-in. O.D. the difference in price is thus of the order of £10 per ton, which is approximately 9% of a total average price for typical tubular trusswork of, say, £112 per ton* (i.e. 1/- per lb.) including fabrication and erection. (There seems to be little difference in the cost of fabrication between tubular work and welded rolled steel). Even with bowstring trusses of spans greater than 100-ft. —costing approximately £125 per ton erected—where the larger tubes (over 4½-in.

* Costs given in the text are exclusive of surface preparation and painting.

Sheds in the Port of London—*continued*

Table 2. Particulars of Sheds.

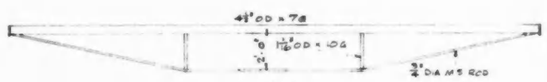
NUMBER LOCATION & FLOOR AREA	DIMENSIONS & TYPICAL SECTIONS	FOUNDATIONS	SHED PAVING	ROOF & SIDE CLADDING	GUTTERS & DOWNPIPES
1-5 ACORN YARD 121,000 SQ. FT.		4-12" SQ. × 30' LONG R.C. PILES PER COLUMN	6" R.C. SLAB ON ROLLED HARDCORE	'BIG SIX' CORRUGATED ASBESTOS CEMENT ROOF SHEETING. 18 S.W.G. GALVANISED CORRUGATED M.S. SIDE SHEET'G.	GALVANISED M.S. GUTTERS 27" GIRTH-EAVES 38" " VALLEYS 1-6" DIA. C.I. DOWN-PIPE PER 125' RUN
5 JUNCTION DOCK INDIA & MILLWALL DOCKS 37,000 SQ. FT.		R.C. FOOTINGS 10' × 7'-6" & 7' × 5'-6"	DITTO	'BIG SIX' ROOF SHEETING 18 S.W.G. ALUM'N. TROUGH SIDE SHEETING	ASBESTOS GUTTER 42" GIRTH 9" DIA. C.I. DOWN-PIPES; 1 PER SIDE AT END
4 ROYAL VICTORIA DOCK 145,000 SQ. FT SHED 16,000 SQ. FT. CANOPY		2-14" SQ. × 40' LONG R.C. PILES PER COLUMN	DITTO	18 S.W.G. ALUM'N TROUGH ROOF & SIDE SHEET'G.	GALVANISED M.S. GUTTER 40" GIRTH 9" DIA. C.I. DOWNPIPES 1 PER 75' RUN
8 MILLWALL DOCK OUTER 32,000 SQ FT		MASS CONCRETE BASES 10' × 5' × 4'-6" DEEP	DITTO	DITTO	GALVANISED M.S. GUTTER 48" GIRTH 9" DIA. C.I. DOWN-PIPES; 1 PER SIDE AT END
6 MILLWALL DOCK INNER 52,750 SQ. FT.		MASS CONCRETE BASES 10' × 5' × 5' DEEP	DITTO	DITTO	GALVANISED M.S. GUTTER 30" GIRTH 10" DIA. C.I. DOWNPIPES 1 PER SIDE AT CTR.

O.D.) account for approximately 40% of the weight it is usually possible to make worthwhile savings in cost compared with trusses consisting entirely of rolled steel sections. These savings are made possible, in spite of the higher cost per ton of tubes, by the comparatively low overall weight of the trusses which can be achieved. (Table 3).

Roof framework

In order to minimise the increase in the weight of roof steelwork, inevitable with the larger spans, close attention has been paid to the relative economies of different roof shapes, spacing of trusses and design of purlins. It is commonly accepted that conventional pitched roof trusses are uneconomic at spans greater than 80-ft. The absence of a tie 20-30-ft. above ground in a wide-span portal frame (itself of no particular advantage in a shed requiring *everywhere* a minimum clear operating and stacking height) leads to section sizes and weights in the main members considerably greater than those required in a tied roof frame[1]. Accepting further the axiom[2] that for maximum economy the roof loads should be transferred to the ground in the most straightforward manner possible, i.e. without secondary girders or trusses, the choice generally lies between arches or bowstring truses mounted on cantilever columns. (The case of the timber storage sheds at Acorn Yard, Surrey Commercial Docks, is a special one). Both types of roof are eminently suitable for the 100-ft.-200-ft. range of spans, and should also be very competitive in the 40-ft.-100-ft. range.

With sliding door openings 20-ft. wide in the sides of the shed the optimum truss spacing for minimum weight and fabrication—and hence cost—has been found to be 25-ft. A problem arising from this truss spacing was the design of economic purlins capable of spanning 25-ft. when spaced at 4-ft. 6-in. or 9-ft. centres for asbestos and aluminium alloy roof cladding respectively. The purlin rule for tubes of B.S.449 has led to the use of the somewhat heavier single tube purlins for a spacing of 4-ft. 6-in., requiring at the same time the minimum of fabrication. For the 9-ft. spacing a specially designed and tested trussed tube purlin (Fig. 1) has been adopted. This type of purlin weighs only 10-lbs. per ft. run, equivalent to 1.1-lbs./sq. ft. of floor area and costs approximately £113 per ton erected.



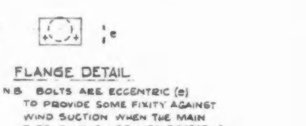


Fig. 1. Trussed Purlin.

Wind girders and portals

Wind forces acting on the shed gables have to be collected by horizontal lattice girders or portals placed usually at both tie and rafter level, and are thence taken into the ground via the side column bracing. Where a shed exceeds 300-ft. in length additional intermediate wind girders are provided. Conventional practice has been followed, the truss or arch ties, suitably strengthened, acting as wind girder booms. In the case of the bowstring sheds, which also have the advantage of reducing the areas of the roof and gable ends to the practical minimum, it was thought uneconomic to provide wind portals 25-ft. deep. Portals

of shallower depth were substituted, the additional boom being "bracketed-out" from the gable columns. (Table 2).

Care has been taken to avoid unsightly connections and a certain amount of site-welding of diagonals has been unavoidable. For end-to-side site welds of tubes the half-cup type of connection (Fig. 2) is preferable to a direct fillet weld[3]. The additional amount of shop-welding and the work involved in swaging the ends of the tube are more than offset by the natural support during site welding and the tolerance in length provided by the half-cup. Moreover, normal end shaping of the tube is not required.

Table 3. Particulars of Steelwork.

SHED	WEIGHT OF STEELWORK PER SQUARE FOOT OF FLOOR AREA (LBS.)								CLEAR HEIGHT OF SHED TO TIE LEVEL (MIN'M.)	TOTAL TONNAGE	ROLLED STEEL % WEIGHT	TUBULAR STEEL % WEIGHT	PAINTING SPECIFICATION	AVERAGE COST OF STEELWORK ERECTED & PAINTED/TON	YEAR OF CONSTRN.	REMARKS
	PURLINS	TRUSSES & TIES	MAIN GIRDERS	WIND PORTALS GIRDERS & BRACING	MAIN SIDE & GABLE COLUMNS	SHEETING RAILS	MISCELLANEOUS	TOTAL								
1-3	1·0	1·5	2·2	0·2	1·4	0·2	0·2	6·7	21'-6"	964	2	98	WIRE-BRUSHING PLUS THREE COATS OF PAINT	£124	1956	APPROXIMATELY $\frac{1}{3}$ OF SHED IS OPEN SIDED
5	1·0	2·0		0·6	1·0	0·1	0·2	4·9	31'-6"	82	1	99	FLAME CLEANING PLUS FOUR COATS OF PAINT	£134	1957/8	FIRE DIVISION WALL ON ONE SIDE – R.C. COLUMNS & BRICK PANELS
4	1·9	3·5		1·4	1·9	0·5	0·4	9·0	20'-0"	648*	40	60	PICKLING & PHOSPHATING PLUS FOUR COATS OF PAINT	£142	1959/60	APPROXIMATELY $\frac{1}{10}$ OF SHED ARE OPEN SIDED LOADING BAYS
8	0·6	1·6		0·7	2·0	0·4	0·7	6·0	21'-6"	87	53	47	DITTO	£130	1959	
6	1·0	2·1		0·6	1·7	0·3	0·6	6·3	21'-0"	140	49	51	DITTO	£134	1960	

* INCLUDING COVERED LOADING BAY

Limitations of tubular members

The tube, having a constant radius of gyration in all directions, is the ideal section for a strut provided it is propped against buckling in 2 directions at the same points. Where it is not convenient to arrange this—as in the main tie of a bowstring truss subject to stress reversal (Fig. 3) the choice will lie between a single rolled section such as a channel, twin battened rolled sections or twin battened tubes.

The chief limitations of tubes are, of course, those imposed by their section modulus in bending, and they have not, on the whole, been found to be competitive with rolled sections, either as single or as twin battened (or latticed) cantilever shed columns. Recent work in Germany[4] in testing tubular cantilever dolphins has indicated that the actual yield stress in bending is rather higher for tubes than that calculated by the simple bending theory. However, it is likely that this is only significant with tubes of larger diameters, and considerable experimental work still remains to be done in this country before there is any likelihood of a general acceptance of higher permissible bending stresses in tubes.

Tubes are normally ordered from the drawing board and there are no sizeable stocks held by the manufacturers or by stockists. There is thus no period of open storage which weathers the millscale and enables it to be removed by wire-brushing. This makes it advisable to specify one of the more superior—and costly—methods of surface preparation, i.e. pickling and phosphating, flame cleaning, or shot-blasting, to avoid the risk of an untimely paint failure. However, this no more than follows good-class practice, and the additional initial cost can be set against the consequent reduction in maintenance.

Problems of size

The scope of this article only allows a brief examination of some of the special problems that arise with tied roof structures mounted on cantilever columns and spanning 150-ft. or more.

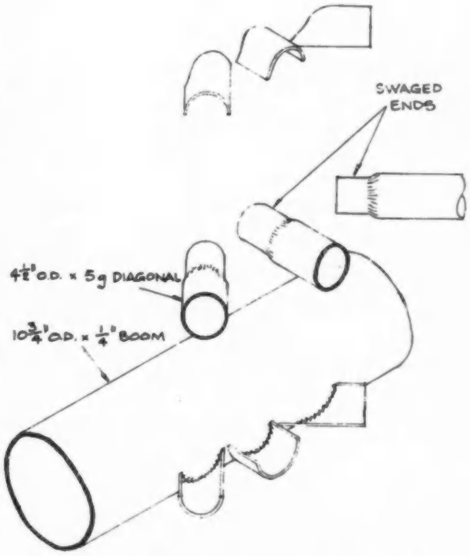


Fig. 2. No. 4 Shed. Typical wind portal joint with site welded half cup connections.

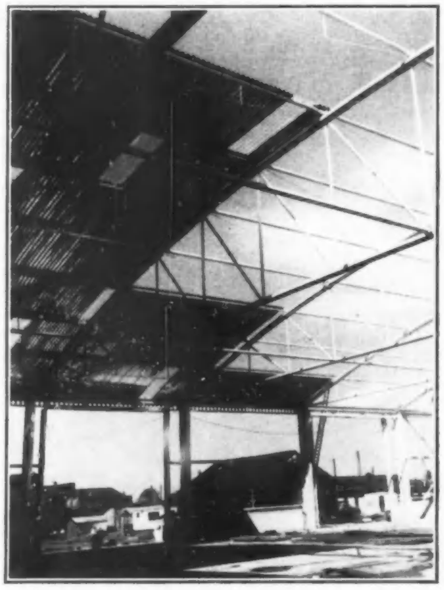


Fig. 3. 'G' Shed, Millwall Dock (Inner) 150-ft. span bowstring trusses with m.s. channel lower boom. Sheeting in progress.

(a) Roof loads

The tied-arch roof of the 200-ft. span transit at No. 4 Berth, Royal Victoria Dock[5], was considered to be too large to be designed only for a *uniform* snow load of 15 lbs per sq. ft. It was thought possible that snow could melt on one side of the roof only, or, alternatively, that it could be blown into ridges or from one slope to the other. For this reason the purlin props were not assumed to stabilize the bottom booms of the arches for which channels were provided rather than single tubes. Non-uniform loading conditions are more serious in the case of an arch than in the parabolic

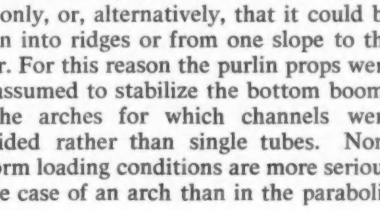


Fig. 4.

bowstring truss. The latter acts as a tied arch under uniform loads (the diagonals being un-stressed) and as a truss under non-uniform conditions.

(b) Strain and temperature movement

For the larger roof spans it was necessary to calculate the effect of changes in the length of the principal members, due to load and temperature variation, on the cantilever columns. (With a three-pinned tied arch this need only be done for the tie, as the arch itself is virtually free to rise or fall). For stretch under snow loading the force exerted at the top of the column is given by equating the deflection of the column and half the total extension of the tie, i.e. for equilibrium.

$$\frac{\Delta}{2} = \frac{PL_C^3}{3\,EI_C} = \frac{(F - P)\,L_T}{2\,A_T E}$$

$$\text{hence } P = \frac{F}{\frac{2}{3}\frac{A_T L_C^{\;3}}{I_C L_T} + 1} \qquad \text{(Fig. 4)}$$

where

P = Horizontal force acting at the top of the column

L_C = Length of column

I_C = Moment of Inertia of column
E = Young's Modulus of Elasticity
F = Calculated force in the tie
L_T = Length of tie
A_T = Cross-sectional area of tie.

For a change of temperature it is sufficient to consider only the change of length of the main tie, and the force F_T required to prevent any thermal movement is given by

$F_T = E A_T \propto t$, where $\propto$ is the coefficient of linear expansion.

The change of length δ which is prevented by F_T is $\dfrac{F_T\ L_T}{A_T E}$ and also $\propto L_T t$.

In practice, the columns offer *some* resistance P_T to thermal movement and are in turn subjected to forces P_T.

If the total actual change of length is $\triangle$,

then $\dfrac{\triangle}{2} = \dfrac{P_T L^3_C}{3EI}$ Fig. (5) and

$P_T = f_T A_T$ where f_T is the resulting stress in the tie.

Substituting η E for f_T, where η is the actual strain in the tie,

$$P_T = \left(\frac{\delta - \triangle}{L_T + \delta}\right) EA_T \text{ (Fig. 5)}$$

$$\text{Hence } P_T = \frac{\propto t\ E}{\dfrac{1 + \propto t}{A_T} + \dfrac{2\ L_C^3}{3\ I_C\ L_T}}$$

An outward force P, caused by the load F_T in the tie due to full snow and dead load on the roof, and a force P_T, caused by a temperature expansion, are never cumulative as expansion cannot coincide with snow loading. An inward force P due to wind suction and a force P_T due to temperature contraction will, however, be additive.

The normal steel shed column is sufficiently slender to keep P or P_T within quite manageable limits, and the effect of P on the tie is always to reduce the load carried by it.

Expansion joints along the the length of the shed were provided in the sheeting rails, gutters, purlins and longitudinal ties at No. 4 Berth, Royal Victoria Dock. (Fig. 6).

(c) **Gable columns**

At that shed the apex of the roof is 40-ft. above tie level. The gable columns which are normally designed as beams, spanning between ground, wind girder or portal at tie level and rafter wind girder, were not connected to the rafter wind girder in this instance, but were designed to cantilever above tie level so as to avoid indeterminate overturning moments, induced by the wind reaction at rafter level, in the roof structure as a whole.

(d) **Truss bearings**

A simple, but effective, truss seating (Fig. 7) on the columns has been designed for the larger-span bowstring trusses. The degree of restraint which can develop is negligible and the detail satisfies the theoretical requirements of a pin joint. The bolts holding the trusses to the columns—as, indeed, all other bolts in the sheds—are sherardised high tensile bolts to B.S. 1083 with a minimum ultimate strength of 45 T/sq. in. For the arches at No. 4 Berth actual pin joints were provided. (Fig. 11).

(e) **Transport, site-welding and erection**

The steelwork was dispatched to the various docks by water, rail and road. Bowstring trusses have to be limited in depth to 14-ft. 6-in., the maximum possible for road transport, which presents no difficulty in the economic design for spans up to 150-ft. The bowstring trusses are normally dispatched from the contractor's works in 3 lengths, and are butt-welded on the ground and lifted into position by mobile crane.

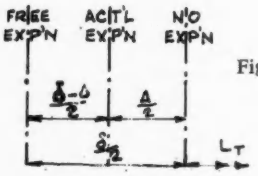


Fig. 5.

In the case of No. 4 Shed, Royal Victoria Dock, the arches were dispatched in quarter lengths, 60-ft. long, the practical maximum length for transport, and site welded into half-lengths on the ground.

Before hoisting the roof members into position the contractor was instructed to line, plumb and grout the columns on one side of the shed, leaving the other row of columns free for plumbing and grouting after erection of the roof members and extension of the ties under dead load.

The erection procedure was as follows:-

(i) Lift half-trusses (weighing 2.6 T each) on to columns by derrick-crane and erection mast, secure pin joints at shoes and apex, and bolt hangers on both halves of main tie to the trusses.
(ii) Using lifting gear on the erection mast adjust centres between pins and column caps to 200-ft. and butt-weld main tie centre joint.
(iii) Fix purlins and longitudinal ties and release trusses from lifting gear. Plumb and grout second line of columns.

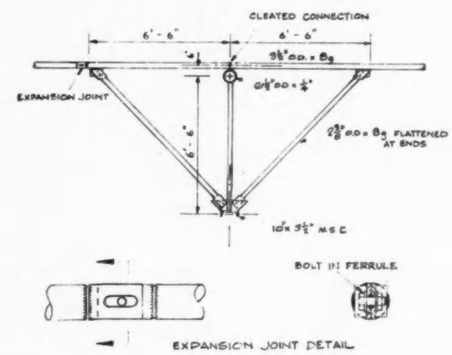


Fig. 6. Purlins and purlin props, No. 4 Shed—200-ft. span.

A rate of progress of three bays of roof steelwork per week was achieved by an erection gang of 6 men at the peak of the contract.

Mechanical and structural tests

Test certificates were obtained from the tube manufacturers for all tube sizes used. The minimum yield stress for tubes within the continuous weld range (up to and including 4½-in. o.d.) was not less than 16 tons per sq. in. whilst for the larger tubes made by the hot-finished seamless process the yield stress was consistently over 20 tons per sq. in. For both kinds of tubes the ultimate tensile strength was 29-30 tons per sq. in.

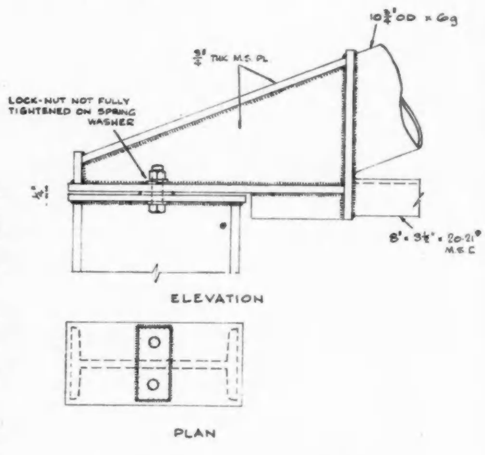


Fig. 7. Truss bearing—'G' Shed. (150-ft. Span bowstring truss)

Loading tests were carried out on a cruciform flanged joint of the type used for the main tie at No. 4 Shed, Royal Victoria Dock (Fig. 8)—a simple tension joint requiring no flange stiffeners and the minimum of welding—and on the trussed purlins. The former was loaded to 1½ times the design loading without permanent strain, and the latter were tested to failure, which occurred when the load reached 2½ times the design load. Tests carried out on samples taken from a curved top boom of a bowstring truss showed that cold-bending had not led to any loss of compressive strength.

Welding inspection

A firm specialising in welding supervision and in the radiographic examination of

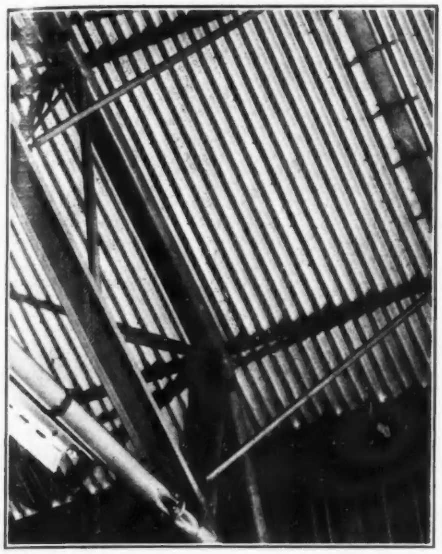


Fig. 8. No. 4 Shed. Cruciform tension joint in tie and m.s. channel bottom boom. Expansion joint in roof sheeting.

welds was appointed to carry out all necessary examinations of works and site welds, including radiographs of the more important site butt welds. Reports submitted by this firm gave details of minor defects and remedial action taken as well as typical "gamma-graphs" of important welds. A satisfactory standard of workmanship was maintained throughout.

Roof and side cladding

The main requirements for the cladding of a dock shed are impermeability, adequate strength, durability with little or no maintenance, and complete incombustibility. In addition, the lower part of the side cladding must have considerable resistance, and the upper part some resistance, to accidental impact from cargo, vehicles, and mechanical handling equipment. Where a shed runs parallel with the quay the roof cladding should be capable of preventing loads—which have been known to be accidentally dropped by quay cranes—from crashing into the shed. The sheds are unheated, and no insulation is provided.

In practice these requirements have been met by 9-in. perimeter brickwalls 3-ft. 6-in. high and corrugated metal side and gable sheeting. In recent years aluminium alloy trough sheeting 18g thick has been preferred as it is virtually non-corrodible. It can also be supplied in a varying pattern, consisting of troughs and flats, which provides a little variety in a large vertical area. (Fig. 9).

Corrugated asbestos-cement sheeting of the "Big-Six" type is still the most inexpensive roof cladding available. It has an estimated life of 30 years and meets all major requirements except resistance to impact from dropped loads. It does, however, restrict the purlin spacing—the maximum is 4-ft. 6-in.—as well as the minimum roof pitch required against rain penetration through the end laps. It is thus less suitable for low-pitched trusses and for the crown part of bowstring trusses. Aluminium alloy trough sheeting 18g thick easily spans 9-ft., a useful dimension for the triangulation of the bowstring trusses, obviating the need for intermediate purlins between panel points with consequent local bending in the rafters. The fit at the laps is sufficiently close for use at a low roof pitch, including all parts of the bowstring trusses. It has, however, been thought advisable to have a minimum lap length of 12-in. (18-in. near the crown), and as the sheets have been used in lengths of 18-ft. the total number of laps has been greatly reduced. Aluminium alloy 'U' bolts 5/16-in. dia. are used for fixing the sheets to tubular purlins and sheeting rails and all side and end laps are sealed by aluminium seam bolts or "break-stem" rivets.

The co-efficient of thermal expansion per degree Fahrenheit for aluminium (14×10^{-6}) approaches that of lead (16×10^{-6}) and is approximately twice as great as that of steel (6 to 7×10^{-6}). Opinions vary as to the need to make special provision for thermal movement, and the usual practice with corrugated aluminium roofing sheets is to rely on the clearance between holes and fixing bolts, and on the resilience of the corrugations. In the case of the No. 4 Shed, Royal Victoria Dock, however, expansion joints for the roof and side sheeting were provided in the expansion bays and at the change of roof slope by means of suitable flashings and slotted holes.

Roof glazing

Conventional patent glazing is durable and incombustible and provides adequate natural lighting. It is, however, considerably dearer than scattered corrugated roof lights, taking into account the cost of the flashings and the areas of patent glazing required—at least two strips per roof slope for larger spans. It also requires heavier and costlier glazing purlins.

The combined areas of scattered roof lights required for a dock shed need be no more than 5-6% of the total floor area of the shed, and a very even distribution of light can be achieved by staggering the sheets (Fig. 10). Used in this way roof lights can reduce costs by as much as 1s. per sq. ft. of floor area compared with patent glazing.

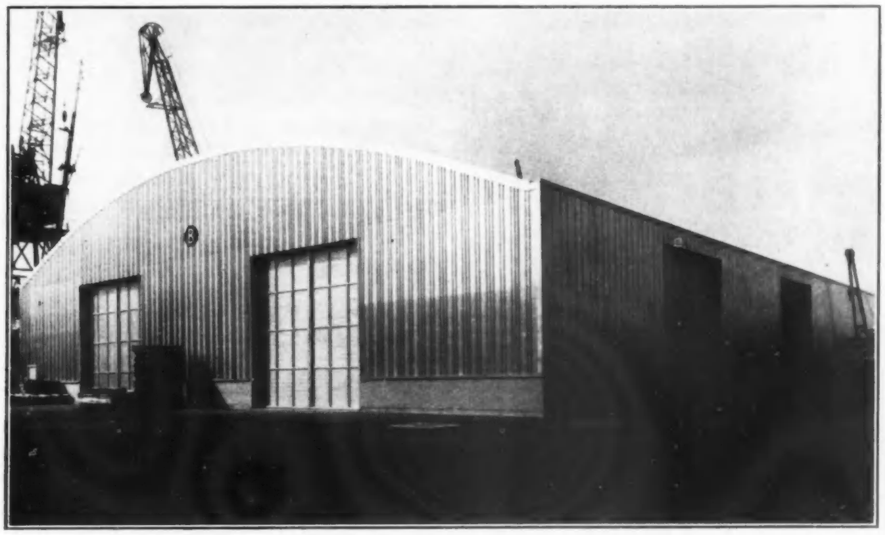


Fig. 9. 'B' Shed. Millwall Dock (Outer)—Span 110-ft.

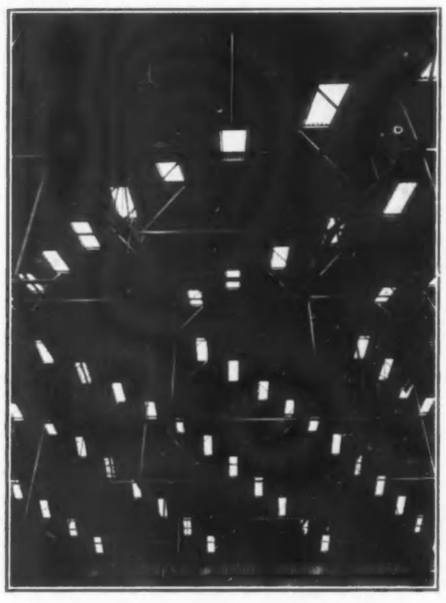


Fig. 10. No. 4 Shed. Royal Victoria Dock. Span 200-ft. bottom boom of arch truss is a m.s. channel. Remainder of roof is of tubular steel. Roof lights are staggered for even light distribution.

A corrugated reinforced glass type of roof light has been used in conjunction with "Big-Six" asbestos-cement roof sheeting, one of the few matching profiles available for this type of glazing. Polyester resin-bonded sheets of glass laminate, of good quality and fire resistance, were specified to match the profile of the aluminium alloy roof sheets.

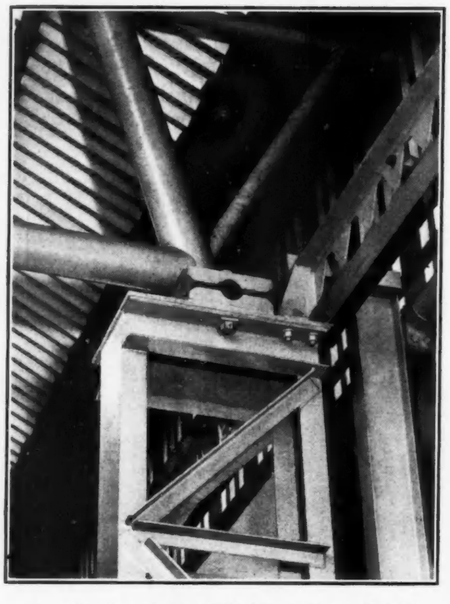


Fig. 11. No. 4 Shed. Column cap and arch bearing. Sliding door track between sheeting post and main column.

Sliding doors

Much attention has been paid to the design and positioning of the sliding doors. They have been kept within the shed walls, but on the outer side of the columns in order to save floor space and to reduce the risk of damage. Separate sheeting posts are provided with connections to the main columns at column-cap level (Fig. 11). The doors are in two leaves, top-hung, and two stout "ploughs" fixed to the bottom rail of each leaf, slide in a small cast iron channel let into the concrete slab.

The conventional sliding doors in a London dock shed consist of steel angle framing with 18g galvanised corrugated steel sheeting as cladding. The cost of a two-leaf door of this type for an opening of 20-ft. x 20-ft. is approximately £300, inclusive of sliding gear.

The doors of the new plywood shed at Acorn Yard, Surrey Commercial Docks have welded rectangular hollow steel tubes for their framing, and the cladding is coloured glass fibre laminate on pressed steel sub-frames.

The doors of the other new sheds are of welded aluminium construction throughout, with small pitch aluminium sheets as cladding (Fig. 9). The main framing consists of aluminium channels, and specially extruded hollow rectangular sections form the secondary framing.

The doors are manually operated, the weight of each leaf being only 4-cwt. The cost of a two-leaf aluminium door (20-ft. x 20-ft. opening) including sliding gear, has dropped from £460 when first introduced to £340 for the latest shed.

The tracks of the sliding doors are generally supported from castellated steel channels which are very suitable for supporting light loads on spans of 25-ft. with the minimum of deflection. The channels are "stayed" against twisting which could otherwise be caused by the eccentricity of the door track brackets.

Gutters and downpipes

The elimination of valley gutters and their downpipes and runs of underground drains is one of the advantages which result from the use of single-span roofs. The side

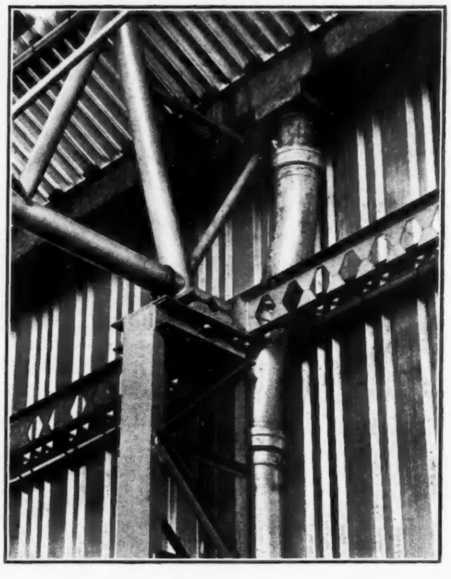


Fig. 12. No. 4 Shed. 9-in. dia. C.I. R.W.P. every 75-ft.

gutters, which are of the internal boundary type, have been designed to cope with the additional run-off from the roof. (Fig. 12). Moreover, downpipes have been kept to a minimum, the number and position depending on the siting of the shed in relation to the dock (the most convenient outlet) and existing underground drains in the vicinity. In most cases it has been possible to provide a single downpipe which has been as large as 12-in. diameter for a run of 350-ft. The cross-sectional area of the gutter, which has in any case to be approximately 18-in. wide to make it walkable for cleaning, has been calculated, and the results of recent research into the problems of flow in level and sloping gutters[6] have been applied to the latest shed (Fig. 13). The gutters consist of long lengths of galvanised mild steel, spanning 25-ft. between column supports, which are site welded into a continuous length of 350-ft. A single downpipe 10-in. in diameter with a rounded outlet is provided in the centre of each run, and provision for expansion is made between the gutter cleats and certain column supports. The gutters are laid to a fall of 1-in. in 50-ft., but the top of the inner vertical leg is kept level by means of a welded fillet of varying depth which provides a support for the roof sheeting. The place of one purlin and one sheeting rail is taken by the gutter and its stout aluminium side flashing.

The gutter has been designed for a rainfall intensity of $\frac{1}{3}$-in. in five minutes. On the very rare occasions when this may be exceeded—once in 20 years, statistically speaking,—the flashed outer leg, being lower than the inner leg, provides a continuous weir which enables the water to overflow on the outside of the side sheeting. Where asbestos-cement roof sheeting is used it may, on occasion, be found more consistent and cheaper to provide either standard or purpose-made asbestos-cement boundary gutters of the spigot and socket type, which can be supplied in 6-ft. length. They have to be supported on straps at 3-ft. centres and do require special eaves purlins and sheeting rails. It is not possible to provide a side-weir overflow against the rare exceptional downpour, and a fall can only be provided by making every strap of different length. On balance, therefore, the

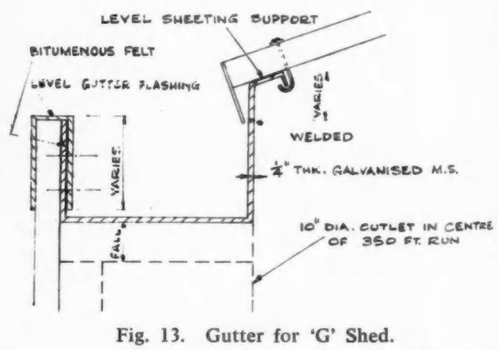


Fig. 13. Gutter for 'G' Shed.

galvanised steel gutter described above, which also has some structural value as an eaves beam, appears to meet all requirements with regard to strength, durability and avoidance of internal joint leaks and overflow. It costs approximately 43s. per foot run erected, but the cost of one purlin and sheeting rail—say 10s. each per foot run—are saved, and the cost of downpipes and underground drains is very low by comparison.

Foundation and shed paving

The upper ground strata in the vicinity of the docks are frequently fill and silty

Fig. 14. No. 1-5 Shed, Acorn Yard, Surrey Commercial Docks. Umbrella roof structure. Triangular wind girder carried on 4-legged column.

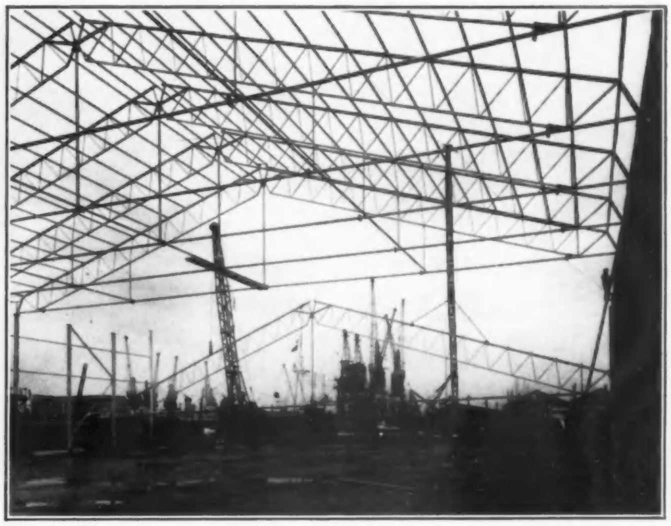


Fig. 15. No. 5 Shed, Junction Dock, 125-ft. Span. Erection of trusses.

clay, with safe bearing values of 0.5 T to 1 T per sq. ft. The decision to pile the shed column foundations was taken only for No. 4 Shed, Royal Victoria Dock, where peat was known to be present, and for Nos. 1-5 Sheds, Acorn Yard, Surrey Commercial Dock, where the total number of columns was small and the wind forces for the open-sided shed, 31-ft. high at the eaves, were found to be particularly severe.

Elsewhere, the choice has been between mass concrete and reinforced concrete column footings, the former having a slight cost advantage in depths up to 4-ft.

All shed floors are reinforced concrete 6-in. thick on hardcore consolidated with 8-ton rollers. Reinforcing fabric weighing 7.3-lbs./sq.yd. is provided in the top of the slab. The only exception is the hardwood section of Nos. 1-5 Shed, Acorn Yard where only the 12-ft. wide alleyways were concreted, the remainder of the floor being rolled ashes on hardcore.

Aesthetic considerations

An attempt has been made to produce designs which are aesthetically pleasing as well as economical, subject, of course, to the limitations of a low-cost cargo shed. The light and open welded framework—both rolled and tubular—and the curved roof-line of the bowstring trusses, help to produce clean lines. Some variety is provided in the elevations by the vertical pattern of the aluminium side cladding together with the facing bricks and the pronounced coping of the perimeter brickwall.

The detailing of the door openings and of the sliding doors themselves has been influenced as much by aesthetic as by practical considerations, and a small-pitch aluminium trough sheet of improved stiffness was specially produced as door cladding for the most recent sheds. The sheets have been used with the troughs running horizontally to provide a contrast to the vertical pattern of the aluminium side sheeting.

Contract arrangements

The contract for the superstructure of Nos. 1-5 sheds, Acorn Yard, was negotiated with Tubewrights Ltd. and the detailed design of the umbrella roof structure was prepared by them. All subsequent designs were prepared entirely by the Authority's engineering department and were, together with specification and bills of quantities, the basis of competitive tendering. No. 5 Shed, Junction Dock was originally designed with an umbrella roof structure in riveted rolled steel, but the contractors selected for tendering were permitted to submit additional tenders based on their own designs. The two lowest tenders were for tubular steel structures, one for an umbrella roof and the other for a tied arch, the latter being the cheapest. In the case of "G" Shed, Millwall Dock (Inner) contractors were again afforded an opportunity to submit alternative tenders based on their own designs, but the lowest tender received was for the Authority's tubular bowstring truss design. The policy of inviting, whenever possible, additional tenders to the contrac-

Fig. 16. No. 5 Shed, Junction Dock. Clear height to ties of 31-ft. 6-in. for mobile crane operation.

Fig. 17. No. 4 Shed, Royal Victoria Dock. Shed and western covered loading bay. Loading banks 20-ft. wide.

tors' own designs is continuing and enables a check to be made on the competitive character of the Authority's designs at a time of rapid technological changes.

SOME PARTICULARS OF THE SHEDS

(a) Nos. 1-5 Shed, Acorn Yard, Surrey Commercial Dock

This shed replaces a timber shed which was destroyed during the war. In recent years there has been a large increase in the volume of plywood entering the Port and it was decided to provide covered and enclosed storage for this commodity, as well as covered open-sided storage for hardwood and softwood, with a brick fire diversion wall separating the two storage areas. It was, however, a design requirement that both sections should be convertible for whichever type of cargo—plywood or timber—showed a preponderance in the future. To achieve the required flexibility it was necessary to keep the number of columns to a minimum, and a span of 125-ft. was desirable for a common stacking module.

The timber section of the shed requires a clear height of 31-ft. 6-in. to allow mobile cranes to operate.

The main columns were detailed as four battened tubes, with the downpipes central within the columns. The main girders along the outer rows of columns were designed as triangular wind girders. (Fig. 14).

(b) No. 5 Shed, Junction Dock, India and Millwall Docks

Additional storage space for hardboard and linerboard has been provided in this shed, and provision has been made for doubling its area by constructing one side as a brick fire division wall with reinforced concrete columns. This accounts to some extent for the exceptionally low weight of the steelwork (Table 3). The rolls of linerboard are handled by mobile cranes requiring a height of 31-ft. 6-in. to main ties.

Virtually all the general building work was completed before erection of the steelwork commenced. (Figs. 15 and 16).

(c) No. 4 Shed, Royal Victoria Dock

The shed is the central feature of the development of the site as a two-ship berth whose boundaries did not permit the shed to extend over the greater length of the 1,250-ft. quay[5]. The shed was therefore given a width of 200-ft. in lieu of the usual width of 120-150-ft. (Figs. 10 and 17). Raised loading platforms 20-ft. wide x 3-ft. 3-in. high are provided along the ends and the rear side. The shed floor slopes up at 1 in 90 from the quay to the rear loading bank, and the access roads to the quay at both ends of the shed are generally kept at the lower level, 3-ft. 3-in. below the shed floor, except for short ramps at 1 in 15 close to the quay.

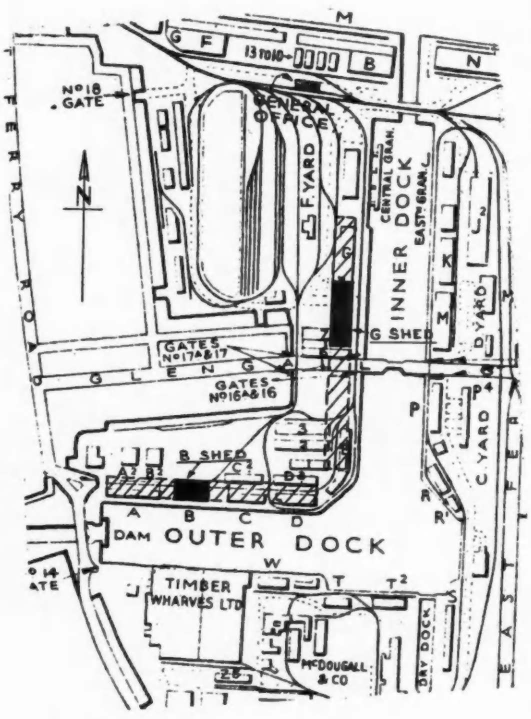


Fig. 18. Key Plan showing B and G sheds and proposed redevelopment, Millwall Dock.

Mobile cranes will not be required to deal with the miscellaneous cargo of this berth within the shed, and a clear headroom of 31-ft. 6-in. has only been provided under the covered loading bays. The mechanical equipment operating within the shed consists mainly of fork lift trucks and straddle loaders and the clear height to tie level is therefore 20-ft.

The 64-ft. wide road at the rear of the shed has two flush paved rail tracks along the loading bank, and additional sidings are provided to the rear of an extensive open-storage area south of the road.

A two-storey office block, a gear store, battery charging slab, substation and latrines complete the berth. The new facilities have been provided for the United States Lines with whom the Authority has concluded an agreement. The berth was formally opened early in April.

Table 4. Approximate Costs.

SHED	CONTRACTOR		COSTS (£)					YEAR
	GENERAL BUILDING WORK	SHED SUPERSTRUCTURE	FDTNS., FLOOR, BRKWK. DRGE., & ELECTC. LTG.	STEELWORK INCL'G ERECTION & PAINTING	ROOF & SIDE CLADDING GUTTER & DOWNPIPES	TOTAL	PER SQ.FT. OF PLAN AREA	
1-5	J. MOWLEM LTD.	TUBEWRIGHTS LTD	47,000	45,000	35,000	127,000	21/-	1956
5	DITTO	DITTO	26,000	11,000	14,000	51,000	27/6	1957/8
4	HIGGS & HILL LTD.	DITTO	56,000	92,000	68,000	216,000	26/9	1959/60
B	J. MOWLEM LTD.	DITTO	12,000	12,000	20,000	44,000	27/6	1959
G	DITTO	DITTO	25,000	20,000	24,000	69,000	26/-	1960

(d) **"B" Shed, Millwall Dock (Outer)**

The construction of this general cargo transit shed completes the first stage of the re-development of the whole of the north side of Millwall Dock (Outer) (Fig. 18).

The width of the shed, which is less than the generally accepted minimum of 120-ft., as well as the absence of a loading bank are largely due to the limitations imposed by the layout and levels of the existing quay. roads and rail-tracks (Fig. 9). (The view is sometimes expressed that forklift trucks have rendered loading banks unnecessary, and that a better vehicle circulation is achieved by omitting them).

The demolition of the old shed on this site and the fabrication and erection of the new shed, together with ancillary building works, were completed in five months.

(e) **"G" Shed, Millwall Dock (Inner)**

This shed, together with extensive road and rail improvements, forms the first stage of the redevelopment of the west side of Millwall Dock (Inner) which, when completed, will be linked to the re-developed north side of Millwall Dock (Outer) (Figs. 3 and 18).

The layout and levels of the site permitted the shed to be made 150-ft. wide, with loading banks at the rear and the southern end. The access road to the quay is again kept 3-ft. 3-in. below loading bank level, with a short approach ramp to the quay.

Conclusions

The trend towards cargo sheds of larger roof spans of the order of 120-150-ft. for the Port of London Authority appears to have been justifield financially (Table 4) and to have become firmly established, and several new sheds are being planned on this basis. (Spans of the order of 200-ft. will not generally be required where the shed can extend over the greater part of the length of a berth.) The bowstring truss and welded lattice steel design still hold their own, and refinements in design, such as the use of grade 20 steel for the larger rafter tubes and twin battened tubes in lieu of channels for the main ties, will help further to reduce costs. There is, however, no question of discarding rolled sections indiscriminately in favour of tubes, and each member is designed in the most suitable section.

Acknowledgment

The sheds described in the article were designed and constructed under the direction of Mr. G. A. Wilson, M.Eng., M.I.C.E., M.I.Mech.E., Chief Engineer of the Port of London Authority, by whose kind permission the article is published.

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Correspondence

To The Editor of the Dock and Harbour Authority

Sir,

Timber in Harbour and Dock Engineering

I have read with interest the series of articles on the above subject, which appeared in the May issue of your Journal.

As you remark in your Editorial Notes, the series form a valuable conspectus of this diverse subject and the survey should prove a useful work of reference to all those concerned with the uses of timber for marine construction works.

I was disappointed to observe, however, that greater reference was not made for our English species, several of which would be most suitable for this type of work.

Britain's woodlands already produce over 100 million cubic feet of timber a year and this figure will increase substantially as more of the new forests come into production. The potential market, with a growing interest by many industries in wood as a raw material, is enormous. Realising the tremendous scope of this versatile material, the Home Grown Timber Marketing Corporation Ltd. was formed in May 1959 as an independent national organisation to co-ordinate the resources of its members and to ensure quality control.

Until the formation of the Corporation no selling organisation existed in this country which was capable of handling bulk supplies. Large contracts were lost to overseas suppliers simply because of the industry's poor structure and inability to co-ordinate its efforts in handling really substantial business. In its dealings the Home Grown Timber Marketing Corporation will be concerned with the industry as a whole and the success of its endeavours will be to the considerable benefit of the nation's economy.

Home Grown Timber Marketing Corporation Ltd.
40 Baker Street,
London, W.1.
24th June 1960.

Yours faithfully,
E. R. A. DREW,
General Manager.

To the Editor of "The Dock and Harbour Authority."

Dear Sir,

The Operation and Administration of Ports

Mr. B. Nagorski's article on "The Operation and Adminstration of Ports" in your issue of April 1960, is interesting and informative.

I am sorry, however, that I must flatly contradict Mr. Nagorski's statement (in paragraph 4 of the section dealing with The Operation of Port Terminals) that, as an undesirable consequence of the fact that very few facilities are operated by the municipal port administration, the port of Rotterdam is short of funds for port improvements as income from rents is not sufficient to meet all financial requirements.

Leaving aside the important question of whether it is justifiable to finance port developments and improvements from annual revenues from rents, etc., I would wish to confirm that, in any case, the port of Rotterdam has been working at a profit and without subsidies, open or concealed.

With the vast development schemes under construction such as the Botlek and Europort projects, it should be obvious to all that the port of Rotterdam is not short of funds for improvements. It is not of course suggested that these projects are financed purely out of profits.

It seems to me therefore that this statement of Mr. Nagorski's, being quite incorrect, is valueless as a commentary on a particular form of port organisation.

Yours faithfully,

Poortgebouw Stieltjesstraat 27,
Havenbedrijf der Gemeente Rotterdam, Ir. Tj. J. RISSELADA
Rotterdam, Netherlands.
25th June, 1960

Erratum

The Operation and Administration of Ports

The Author of the above article has called attention to an unfortunate misprint which appeared in the third paragraph of the second column on page 372 of the April, 1960 issue. The sentence "It has the advantage of eliminating the incentive of competition," should read "It has the **disadvantage** . . ."

Simplification of Shipping Documents

An International Problem

By R. K. BRIDGES
(Member of Council, The Society of Shipping Executives)

Following the example of the General Export Association of Sweden which has achieved the standardisation of no less than 23 forms relating to export shipping, other countries have examined the same problem with the result that the Federation of Danish Industries has issued six standardised forms. Similar action has been taken in Norway and in Finland a committee is actively pursuing the same end, basing their studies on the Swedish set of forms.

All these studies are concerned with the forms required for the *export* of goods and include such general items as Bills of Lading, Mate's Receipts, Insurance Declarations, Customs Entries, Certificates of Origin and Exchange Control Forms.

Obviously, all the various authorities concerned in Sweden, i.e. exporters, shipping companies, insurance companies, Customs, Exchange Control, etc., have been willing to co-operate and have early recognised the fact that such co-operation and simplification of documents is, in the end, of benefit to everybody.

The English Attitude

It is extremely doubtful whether such co-operation would be willingly forthcoming in this country, where each group is deeply entrenched in a multiplicity of its own forms and regards with the greatest suspicion any attempt to come to grips with the problem of standardisation, to help the other fellow.

The British exporter is continually exhorted to export more goods and then more again. He is told his efforts are vital to the survival of our economy and this no one will deny. Is it not, then, time he was able to at least have a say in calling the tune, if he is to pay the piper?

For far too long shipping companies and the Customs authorities in particular, have dictated to the exporter and compelled him to fill in a vast number of differing forms, all aimed at the same end—a brief description of the goods and details of their carriage, i.e. vessel, loading port, destination etc.

These forms could quite easily be standardised into basic patterns, universally acceptable, and the exporter should be invited to take part in the designing of such forms, with an opportunity to express his views and requirements, for let's face it, he is the one who has to fill them in! But if any attempt at this is made, what happens? Practically nothing!

Standardisation of Bills of Lading

In 1947 a Board of Trade Working Party on Export Forms was appointed and its Second Interim Report, issued early in 1949 decided, in relation to Bills of Lading, that they could not be standardised because the carrying provisions of each shipping company vary. This is absolute rubbish.

The Working Party recommended that the shipping companies should be asked to re-design their Bills of Lading to make them all narrow enough to fit a standard 12-in. typewriter, which is general practice in the United States of America and in some Continental countries.

A number of shipping companies *did* adopt the Working Party's recommendation as to width of Bills but there are still a number who have not and as to a standardised form, this has not even been considered.

The Office Management Association has had a Study Group working on this problem for some time and this Group cannot see any reason why a standardised *layout* of the Bill of Lading cannot be produced, even if the shipping companies cannot agree on standard terms of carriage, surely not an insuperable problem. Basically, their risks are the same and it should be a reasonably simple matter to draft a set of clauses covering all the eventualities against which they wish to guard themselves. It only requires the *will* to do this. Underwriters have done it so why not shipowners?

More recently the British Shippers' Council set up a Study Group to consider the same problem but to date no report of their activities is to hand.

Other Export Shipping Documents

Bills of Lading are, of course, only one of the many forms required for the export and shipment of goods.

Customs entries are surely next in order of headaches. Whilst under the present system it might not be possible to produce one standard form to meet all Customs' requirements, it should be possible to reduce the number of individual forms to a very few basic types, all with the same *layout* so that they would marry-in with the other standardised forms. Or is it too much to expect an overhaul of our archaic Customs *system* with the end in view of one form only, for all classes of entry?

In this connection it is interesting to note a recent announcement by the Council of the Chamber of Shipping of the United Kingdom to the effect that *"after discussions and negotiations over a period of years* (my italics) the Government had agreed to the introduction of a simplified manifest for passengers travelling by sea."

" Several years " is too long in these days when the need to give every assistance possible to exporters is urgent. Concerted action should be taken to bring this point home to the Civil Servants, to whom, as we all know, time means nothing and business principles are unknown.

An Enquiry by Shipowners

An interesting development took place in shipping circles last autumn when the International Chamber of Shipping appointed a sub-committee to consider means by which shipping documentation could be simplified and reduced.

But this refers only to the papers required in connection with the operation of the ship and the enquiry is designed to ease the burden of the shipowner's domestic work. It does not refer to the paperwork connected with the shipment of goods.

When the Council of the Society of Shipping Executives enquired of the Chamber of Shipping of the United Kingdom as to the possibilities of British shipowners considering standardising Bills of Lading, the reply was vague and any action in that direction would obviously be in the very distant future, if at all.

Need to Get Together

There is a very great and urgent need to do something about the vast amount of paperwork required in shipping today.

The problem not only involves the shipowner and the exporter but road and rail carriers, lightermen, port authorities, Customs etc. A central committee should be set up, possibly under the auspices of the Ministry of Transport, consisting of members from the Chamber of Shipping (shipowners), British Shippers' Council (exporters), Society of Shipping Executives (shipping managers), Institute of Shipping and Forwarding Agents (agents), Dock & Harbour Board Authorities' Association (docks), H.M. Customs and Excise, British Railways, Road Haulage Association, the Insurance Associations, the Office Management Association and any other interested bodies.

Only then can the problem be examined in its entirety and a solution worked out. It will take time because it is an extremely complex problem in this country but given the goodwill of all parties and a willingness to co-operate for the common good, it could be solved.

But a start should be made at once—time is passing and so are our opportunities for export trade.

The Port of Aqaba, Jordan

Review of Development during the last Decade

(Specially Contributed)

1. Historical Background

QUIETLY and without the glare of international publicity, a new modern port with a substantial traffic has, during the last 10 years, been developed on the Gulf of Aqaba on the Red Sea by the Kingdom of Jordan. In 1950, Aqaba was not much more than a fishing village with rather primitive war-built facilities for unloading military supplies for the Arab Legion on anchorage through lighters. There was no commercial cargo traffic at all, no port administration, no port tariffs and no cargo handling organisation.

Through systematic efforts of the Jordan Government it has been possible, beginning with 1952, to reroute gradually the bulk of Jordanian imports to Aqaba from other ports, to attract several foreign steamship lines, to develop exports of phosphates, to form a nucleus of an efficient port administration and to complete an ambitious but quite realistic major port construction scheme. In this difficult task, the Government has been assisted by several factors. Firstly, facilities built in Aqaba during the last war, made it possible to start port operations on a small scale without waiting for the construction of a new port. Secondly, financial aid from friendly Governments permitted necessary improvements to the war-time installations, and at a later date, a major port extension scheme (mainly from British Development loans). Thirdly, the United Nations Technical Assistance supplied to the Government an international Port Expert (a former European Port Manager), whose advice has been available to the Aqaba Port Authority for several consecutive years.

But the main factor was the consistent will and the necessity for Jordan to obtain an efficient access to the sea on her own territory, in order to make the country economically independent, to save foreign currency on imports and to have an inexpensive and reliable outlet for the export of her excellent mineral products.

In spite of many difficulties and delays the results obtained so far have been almost spectacular. From a modest beginning of 50,000 tons of cargo in 1952—more than half of it military supplies—port traffic rose to 410,000 tons in 1958, and almost 600,000 tons in 1959, mostly valuable imports of commercial general cargo. The erection of a modern fully automatic phosphate handling plant, completed only in August 1959, has increased the possibilities of considerable exports of high-grade Jordanian phosphates which have been scarcely tapped. Previously the sale of phosphates had been hampered by lack of adequate loading facilities, not more than 130,000 tons per year having been shipped via Aqaba in 1958 and 1959.

The development of Aqaba is not only of interest from a purely technical point of view. Although Aqaba has been intermittently used for maritime traffic since Solomon's time, the present phase of her development is an example of a port where everything had to be created anew ; port installations, port administration, tariffs, regulation, staff and an adequate labour force; these have been built up and now, in shipping circles, Aqaba has earned the reputation of one of the best organised ports in the Middle East. It is seldom that ships have had to wait for a berth during recent years and this has occurred only once, in August 1958, in a case of political emergency. Otherwise, ships start discharging or loading straight away upon arrival.

General Economic and Technical Considerations

The Port of Aqaba is the only access to the sea of the Hashemite Kingdom of Jordan. It is located on the southern end of the country, on the Gulf of Aqaba, a long and narrow northern branch of the Red Sea.

Jordan has a population of slightly above 1,500,000 and yearly imports up till recently were in the neighbourhood of 250,000 tons. They consist of sugar, flour, grain, rice, automobiles, tractors, machinery, steel, timber, paper, textiles, petroleum products and various miscellaneous items. As production of domestic grain depends mainly on winter rains, imports of grain increase sharply in years of dry weather. Exports to overseas countries consist almost exclusively of raw phosphates.

Prior to the last war, Haifa was the natural port of the most densely populated northern and western parts of the present territory of Jordan. The distance to Haifa from the capital city of Amman, through the old disused railway, was about 175 klm. while distance to Aqaba by shortest route is 340 klm. However, after the partition of Palestine, Jordan was cut off from this direct access to the Mediterranean Sea and had to divert nearly all foreign imports to the Lebanese Port of Beirut and in part to Lattakia, with transit through Syria.

The distance from Amman to Beirut is not less than to Aqaba. The road has to cross two high chains of mountains, and the territory of three States, Lebanon, Syria and Jordan. Shipment via Beirut necessitates for Jordan a considerable expenditure in foreign exchange, to cover costs of transit and of handling in Beirut. Crossing of state borders may on occasions be subject to formalities and delays; and this may increase the risk of loss of cargo through pilferage or physical damage.

The Jordan Government quickly realised that the country would never be able to improve her strongly negative balance of payment, nor develop exports of her mineral resources, nor achieve any degree of economic independence, unless a full use were made of the only available access to the sea on her own territory. However, serious doubts were voiced by many Jordanian merchants and by some foreign experts whether the creation of a new port in Aqaba, at a considerable distance from the fertile and better developed areas of the country, with no adequate roads or railways, outside of usual shipping lanes, and East of the Suez Canal, would be technically possible and economically justified. Moreover, Jordan, essentially an inlaid country, was short of personnel familiar with port planning and port operations.

In view of these difficulties the Jordan Government applied, in 1951, to the United Nations Technical Assistance Administration for an international port expert, to advise the Government on all aspects of developing a port in Aqaba. The expert arrived in April 1952, first for a general survey and then for assistance in actual port planning and organisation. Once mutual confidence had been established, the Government followed consistently all the basic recommendations of the United Nations expert, instead of accepting—as it sometimes happens with rather negative results — contradictory advice from various well qualified sources, but less familiar with local conditions and requirements.

The following cautious programme of work was established in summer 1952:

1. To start attracting commercial traffic to Aqaba immediately, making use of simple facilities built by the British Army during the last war, with such technical improvements and administrative arrangements that could be done rapidly and at a very moderate cost). (Short Range Programme.)
2. To proceed simultaneously with technical studies and preparation of plans for a major port extension, in accordance with preliminary designs submitted by the United Nations expert. (Long Range Programme.)

Implementation of the Short Range Programme, as outlined under item 1 above, was expected to show whether efforts to divert imports from Western Europe to the Gulf of Aqaba could be successful. It had to provide a practical answer to the question whether or not a major port extension would be an economically sound proposition. The transition time was to be used for establishing a port administration, training personnel, carrying out necessary surveys and studies, and for preparing plans and specifications for a future major port extension.

Local Conditions in Aqaba

Natural conditions are favourable for the establishment of a maritime port in Aqaba. The Gulf of Aqaba, about 100 miles long, is a continuation of the deep, narrow and long depression of the Rift Valley which begins in Lebanon and extends southwards through the Sea of Galilee, the Jordan Valley, the Dead Sea and the Wadi Araba. The Rift Valley and the Gulf of Aqaba are protected by relatively high mountains from the East and the West. Winds normally blow along this narrow corridor from North to South, that is from land to sea in Aqaba, with the result that water in the Bay of Aqaba is very quiet. Only in winter does the wind sometimes change and heavy southerly storms occasionally occur, not more than 2 to 4 times a year, lasting one or two days each time ; then the water is pushed against the northern end of the Bay, causing waves up to 2 metres high.

The Bay of Aqaba is very deep, in excess of 100 fathoms at a distance of 1 mile from shore. In front of the village a sand and coral shelf extends for about 200 metres from shore, with a depth of water of 2 to 3 fathoms. On the western part of the Bay, towards the demarcation line with Israel, there is a sandy beach, with a gentle slope, in direct continuation of the desert like Wadi Araba from which sand is blown into the sea by the prevailing north winds. East of the village, deep water is very near to the shore and the sea bottom has a steep slope.

Ample anchorage grounds are available at a distance of 500 to 1,000 metres from shore, in a depth of water ranging from 10 to 30 fathoms. Twenty-four vessels, medium size and large cargo ships were laying at anchor in the Bay of Aqaba in August 1958. It would have been difficult to accommodate more in the available space between the shore and the line of prohibitive depth of water. Working ships by lighters is very easy in view of the short distance from the anchorage to shore and of the normally calm sea.

The climate is hot but very dry and there is almost all the time a refreshing breeze from the north; the average rainfall is less than 2 inches per year and then only in winter. There is never any fog; visibility is excellent except in case of dust storms which sometimes extend from the Wadi Araba into the western part of the Bay. Land is arid, but there are some palm groves along the coast. There is an ample supply of clean underground water coming through the mountains from the high plateau to the East. The length of Jordan's coastline is about 7 klm., between the demarcation line with Israel on the West and the Saudi Arabian border on the South. The coast of Egypt can be seen in the South West, at a short distance beyond the Israeli settlement of Elath. The small township of Aqaba is located about halfway between the two borders, nearer to the Saudi Arabian side. It has a population of about 6,000 inhabitants.

There is no direct rail connection from Aqaba to the capital Amman. The first 86 klm. of the journey from Aqaba is by a good asphalted road to the railhead Ras-el-Nagb, 5,000-ft. above sea level and on the top of an escarpment. At Ma-an, a further 42 klm. away, the railway joins the Hedjaz railway which was built in the early part of this century to carry Pilgrims from Damascus via Amman, and Ma-an to Medina. The railway track to the South of Ma-an towards Medina was abandoned after extensive damage during the First World War. In effect therefore the railway now runs from Ras-el-Nagb to Amman a distance of 236 klm. The railway is 104 cms. gauge, its capacity is about 300-350 tons per day from Ras-el-Nagb to Amman.

The distance by road from Ma-an to Amman is 230 klm. of which 196 klm. is over a rough desert track. A seven metre wide asphalt road to replace this track is now under construction and should be completed by the end of 1960.

Short Range Programme

Port facilities left by the British Army after the last war consisted of a Lighter Basin known as the Military Basin built on the western side of the village. The basin is enclosed by a wide outer wharf offering about 420-ft. of waterfront on the seaward side with a depth of water of 11-ft. Inside the basin there is a total length of quay of about 900-ft. with a depth of 6 to 9 feet. All wharves were built with Larssen steel sheet piling No. II and No. III.

There are two simple sheds of 1,800 square metres each, on land but one of them is located at a distance of about 120 metres from the waterfront. Paved open storage space is ample on the outer wharf and on the landside of the basin.

The Military Lighter Basin was used for military supplies during the war and again after 1948, when a small British garrison was sent to Aqaba at the time of the Israeli advance to the Aqaba Bay. Since 1949, a regular flow of various supplies came from England to Aqaba for the British Army and the Arab Legion. In 1951 the first commercial consignments of sugar arrived in Aqaba and were handled through the Basin.

It would have been possible to use the Military Basin for both military and commercial cargo and to extend gradually and improve its storage and cargo handling facilities. However, neither the location nor the design of the basin are particularly favourable. During the southerly storms the entire impact of wind and waves is directed towards the northern end of the Bay where the basin is located; even inside the basin, under shelter of the outer wharf, water becomes more agitated than on some better protected parts of the open shore on the opposite end of the village. The entrance to the basin from the sea is not easy for lighters in tow, as it is almost facing the shore and would probably have been better from the navigation point of view had it been turned more to the west and south west; the sheds were quite primitive and too far away from the best parts of the wharves; the only advantage of the basin was ample space for open storage.

In view of the above shortcomings, it was decided in 1952 to leave the basin in the hands of the Army for imports of military supplies and to develop a commercial port in a more favourable location. The British Army started, during the war, the construction of a small lighter wharf south of the village, near a cold storage plant of the Aqaba Fisheries. Only 47 metres of the wharf had been completed, in Larssen steel sheet piling, and a very narrow strip of land, 7 metres wide, had been provided behind the piling.

At this particular place, there is a small bay so that the shore line curves and the face of the wharf is almost facing north. There is a limited area of water in the bay with a depth of 2 to 5 fathoms, which is fully protected from the southerly storms. Lighters and harbour craft take shelter here,

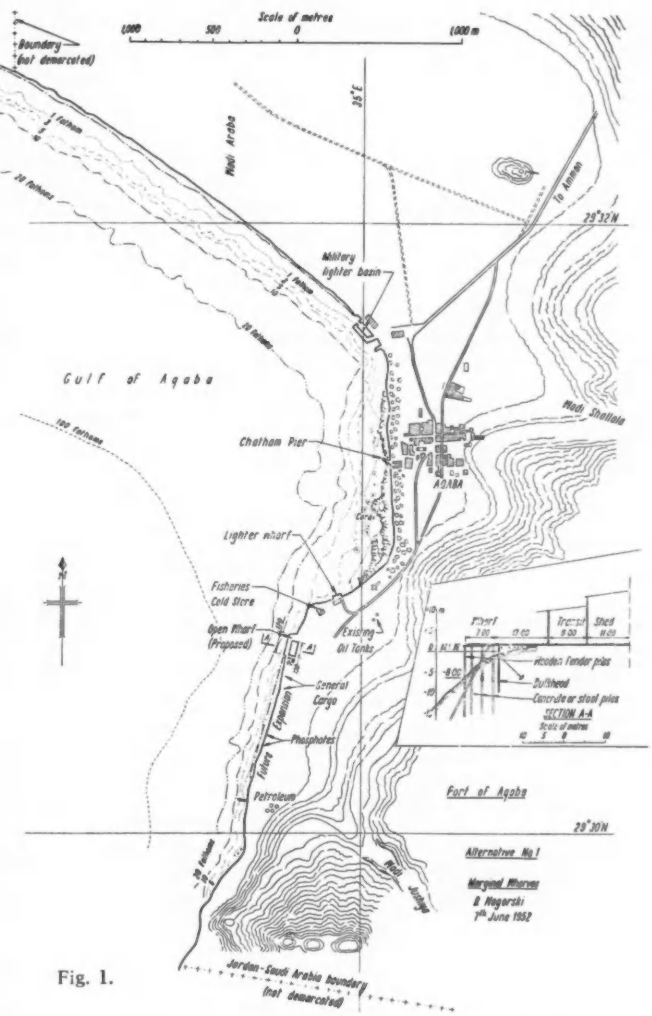


Fig. 1.

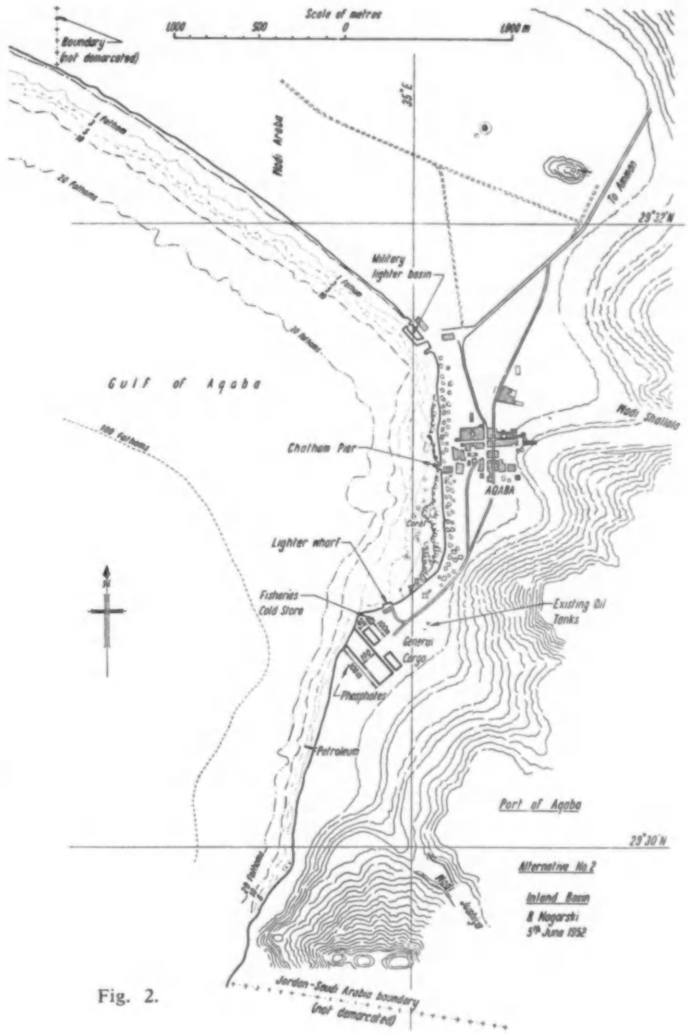


Fig. 2.

especially in winter; the slight swell caused by prevailing northerly winds does not endanger any craft on anchorage nor does it hamper in any way the unloading of lighters moored at the wharf. But the close vicinity of the shallow parts of the Bay, with its coral rocks, prevents the use of this otherwise very favourable location for a deep water port or for any substantial extension of the lighter wharf.

On the U.N. expert's recommendation, the site of the above lighter wharf has been improved and developed for the handling of general cargo. The low ground in the rear has been filled, levelled and paved, and a small but well designed transit shed, 45 metres long, 30 metres wide, has been built, 17 metres from the waterfront. The shed has been designed as a reinforced concrete framed structure with pillars, founded on mass concrete blocks, supporting two spans of steel trusses with corrugated asbestos roofing. The floor is on the level of the wharf on the sea side, and 1.10 metres above the level of the paved area at the rear; it has a 2 metre wide platform for loading cargo into trucks. Ample windows and louvres provide good light and ventilation, while large sliding doors, smooth flooring and the paved wharf facilitate efficient cargo handling. Construction of the shed was started in January 1953 and completed in July 1953 together with all associated filling and paving work. The cost of improving the lighter berth and building the shed was only about £25,000.

Three mobile cranes of 3 ton capacity (Jones KL 44) were purchased in order to gradually replace manual handling of cargo by more economic methods. A connecting asphalted road, 3¾ klm. long, was built from the wharf area through the village to the main highway from Ma-an and Amman. A small storage shed of 800 sq. metres has been provided at the rail head at Ras-el-Nagb, for protection of cargo trans-shipped from lorries to the railway wagons.

Altogether, less than £80,000 was spent in 1953/4 for implementation of the above programme, out of a £100,000 credit allocated by the Jordan Development Board from the first British Development loan of 1952.

As cargo traffic increased rapidly, further improvements had to be made within the short range programme. Additional equipment was purchased, including several mobile cranes, a Neals crane of 3 ton capacity, a Coles "Aeneas" crane able to lift, with outriggers, up to 10 tons, several Jones cranes, KL 44 and KL 66, one of them with two winches for handling a double rope grab; tractors and trailer platforms and fork lift trucks. Since then three small temporary sheds have been added in the rear of the main transit shed. In 1958/59, a heavy mobile crane, model Coles Emperor, of a maximum capacity of 27 tons has been bought to handle the increasing number of heavy lifts. The long delayed extension of the lighter wharf was carried out in 1959 and another shed, a pre-fabricated steel

structure 45 metres by 18 metres has been erected.

For the export of phosphates, temporary arrangements were made at the rear of the lighter wharf, with a large open storage area connected with a temporary and adjoining wharf by a belt conveyor for loading phosphate into lighters. Iron skips were used for trans-shipment from lighters to ships at anchor.

Simultaneously with technical improvements, considerable administrative work was carried out. A semi-autonomous body, Aqaba Port Authority, was established by the law of June 1952 for the administration, maintenance and extension of the port. Operating staff was gradually formed, partly from Palestinian refugees who previously worked in Jaffa or Haifa. A tariff of port dues was introduced as from January 1, 1953, and operating and financial regulations were published and a full custom service established in the port area.

The physical handling of cargo and the lighterage have been very efficiently organised by private contractors who had considerable experience of such work in Haifa and Jaffa. Rates for various services are fixed or approved by the Port Authority and published as an official tariff which the contractors are not allowed to exceed. More than 20 privately-owned lighters from 60 to 200 tons capacity, 2 landing craft of 600 tons, and several tugs from 50 to 250 h.p., are available for the lighterage service.

Development of Port Traffic

The time of implementation and the extent of a major port extension scheme were made dependent, as already mentioned, on the degree of success achieved in attracting commercial traffic to Aqaba. Fortunately, the increase of traffic not only kept step with the temporary technical and operating improvements, but was ahead of most optimistic expectations. With the only exception of the period from August 1956 to June 1957 when traffic through the Suez Canal was interrupted, imports of cargo via Aqaba have shown a steady and rapid increase. Exports of phosphate have been developed also, in spite of the lack of proper loading facilities. The modest and very restricted installations near the Lighter Wharf have been taxed to the utmost and the Military Basin has had to be used to take care of peaks of traffic of commercial cargoes. A considerable proportion of imports of grain, flour and timber was handled in the Basin.

The yearly progress of the port traffic is shown in the table above.

Imports of army supplies are included in these figures, but during the past few years they formed only a negligible proportion of the total. The rapid increase of commercial

CARGO TRAFFIC IN THE PORT OF AQABA

Year	No. of vessels	Imports tons	Exports tons	Total Cargo tons
1952	—	50.850	—	50.850
1953	122	67.665	4.029	71.694
1954	173	80.012	12.339	92.151
1955	222	134.626	66.250	200.876
1956*	155	76.796	77.267	144.062
1957*	104	47.603	99.770	147.376
1958	305	272.405	137.812	410.217
1959	369	453.659	130.658	584.331

*Suez Canal Closed.

imports was made possible thanks to several regular steamship lines which had been gradually encouraged to include Aqaba in their schedule of calls from Western Europe and from the United States to the Red Sea or Eastern Mediterranean ports. Freight rates were slightly higher than to Beirut but the difference was more than offset by cheaper inland transport.

The great test for the Aqaba Port came in summer 1958 when in the confusion following the revolution in Iraq, all the land borders of Jordan were closed. Cargo accumulated in Beirut and had to be reshipped from Beirut to Aqaba by sea, including UNRWA supplies for the Palestinian refugees. Petrol and kerosene, previously supplied from Lebanese or Syrian refineries by road, had to be sent to Aqaba in small tankers or in containers on dry cargo vessels. As a result, port traffic reached 78,850 tons of cargo in August 1958, compared with previous monthly average of less than 20,000 tons.

As the new port facilities were not completed at that time, a temporary traffic congestion unavoidably arose. However, thanks to measures taken by the Port Authority in September 1958 the situation was again well in hand and a steady traffic of about 45 to 50,000 tons per month has been handled ever since, without difficulties and delays.

The memorable events of the summer 1958 gave a striking confirmation to the fact that a well organised port at Aqaba is an essential condition for Jordan's economic and even political independence. Without Aqaba, it would have been extremely difficult to master the serious economic crisis resulting from sudden interruption of all overland imports.

MAJOR PORT EXTENSION

Preliminary Planning

In a study of Jordan's economy made in 1952 the requirements of the Port of Aqaba for the near future had been estimated in 1952/53 approximately as follows:

1. Facilities for handling imports of general cargo, with a considerable proportion of bagged goods, in the total amount of about 150,000 tons per year.
2. Loading equipment and storage space for exports of raw phosphates, within the new 4 to 5 years, up to 300,000 tons per year with a possibility of a gradual but considerable increase in following years.
3. A small oil terminal for the discharge and temporary storage of imported petroleum products, kerosene, petrol and diesel fuel oil, amounting to about 75 to 100,000 tons per year.

For phosphates it was absolutely necessary to foresee a deep water wharf, as loading this low-priced and very powderous commodity through lighters is economically prohibitive and technically difficult. With respect to general cargo, it would have been eventually possible to continue discharging vessels at anchor into lighters in view of favourable natural conditions and of the moderate volume of traffic. However, since deep water berths had to be built for phosphate in any event, it seemed logical to create a deep water port for all commodities, including general cargo as well.

The first and perhaps the most important task of port planning was to find, within the narrow limits of Jordan's coastline, a suitable site offering the best possible protection from rough seas and having enough space for port facilities on land, not only for the above requirements but also for extensions in the more distance future.

The northern end of the Bay, between the village and the demarcation line with Israel had the great disadvantage of being fully exposed to southern storms in winter. The U.N. Port expert proposed therefore in June 1952 to build the new port south of the village, where deep water is very near to the shore and the shore line is parallel to prevailing winds. A wide, slightly inclined, empty plain between the sea and the foot of the mountains offered an excellent site for all installations on land.

As the exceptionally great depth of the sea made the cost of construction of protecting breakwaters prohibitive, alternative schemes were proposed; either open marginal wharves on the existing sea shore or a costly but fully protected inland basin obtained by dredging and excavation on the flat northern end of the above mentioned

plain. The general location and approximate layout of future facilities have been shown on two sketches submitted by the port expert to the Jordan Government in June 1952, as a basis for further more detailed studies (see Figs. 1 and 2). The actual layout of works, as completed in 1959, corresponds almost exactly to the Alternative No. 1, marginal wharves (compare with Fig. 3).

Reference to the photograph (Fig. 4) will show the reader the site conditions with the mountains in the background.

Explanatory borings were arranged in August 1952, with such equipment as was at hand (rotary drill) to determine whether the nature of subsoil would permit dredging of an inland basin. No core samples could be taken with this equipment but soil proved to be sand, gravel, decomposed granite and relatively soft conglomerates. Genuine rock was found in one or two bore holes outside of the eventual dredging area proper. Upon consultation with a United Nations Point IV drilling expert and with a prominent international dredging contractor, it appeared that dredging would be possible although rather costly, perhaps up to 15s. or £1 per cubic metre.

On the other hand, the scheme of having unprotected marginal wharves seemed also acceptable in this particular area, as the prevailing northern winds are parallel to shore and would not press the vessels against the wharves. In general the sea is calm but the use of the wharves would probably have to be stopped during the very short duration of southerly storms for a few days per year.

Detailed technical work, such as site studies and preparation of complete plans, could not be made locally because of the lack of technical staff. The port authority decided therefore to engage a firm of consulting engineers and Messrs. Rendel, Palmer and Tritton of London were invited in December 1952, to make a Preliminary Investigation and Report, and later to prepare full specifications and tender documents for future works.

A local visit was made early in 1953 by a partner, Mr. John Palmer, who discussed all problems with the port authority and the port expert, and in June 1953 submitted a preliminary report. The consultants looked with favour on the marginal wharves scheme of the U.N. expert, but they suggested that the advantages should be examined of building the new wharves in the immediate vicinity of the Military Basin, on its eastern side, in order to have the old basin included in a unified port area. Further, in view of the small volume of commercial imports, which they estimated at 60-70,000 tons per year, the consultants recommended that a lighter wharf be built for

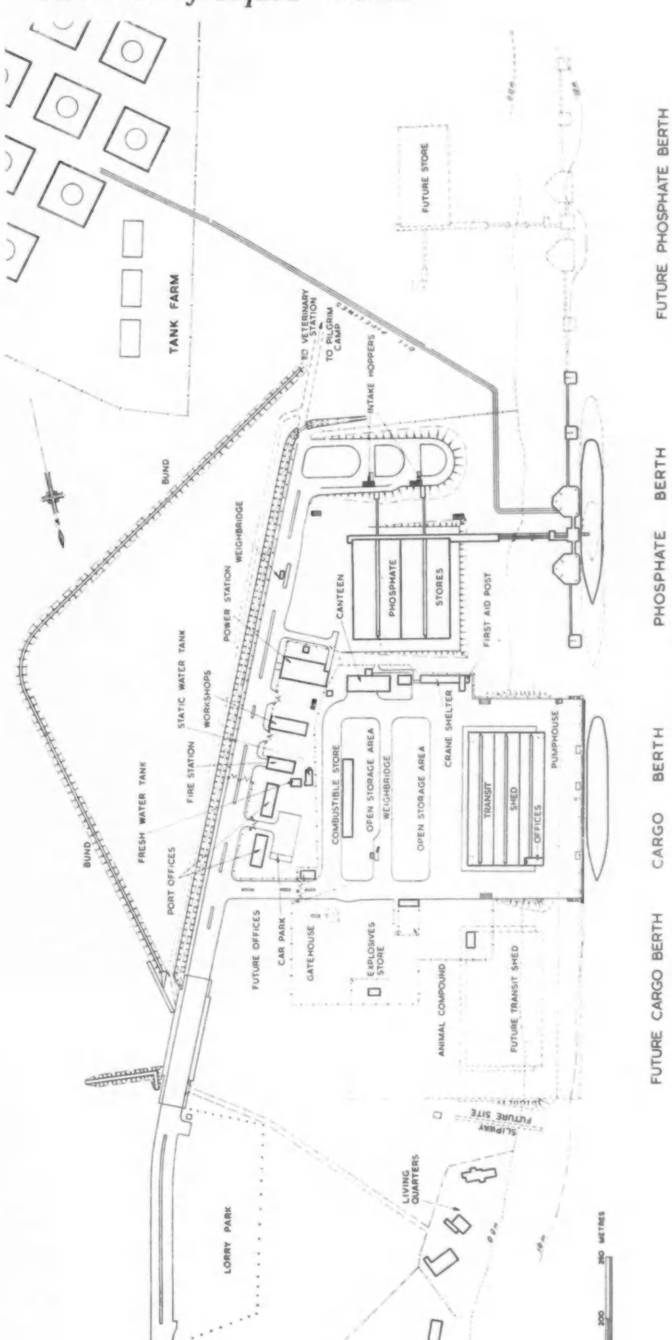


FIG. 3. PLAN OF THE PORT OF AQABA

general cargo instead of a deep water wharf because, in their view, only when civilian imports had risen to a steady 150,000 tons per year, would a deep water berth for general cargo be justified. For phosphates, they recommended that a deep water berth be built in direct continuation of the lighter wharf, towards the south east. Proper depth of water would be reached by filling the shallow part of the bay in front of the village. Should, however, the port authority prefer the site proposed by the port expert, south of the village, deep water berths were suggested in the consultants' report for phosphates and general cargo alike. Costs of works on the two sites were roughly estimated by the consultants to be approximately the same, about £850,000.

As to the inland basin scheme, which meanwhile became very popular in Jordan, the consultants did not think it necessary to undertake any detailed studies because, in their opinion, the cost of dredging would be too high, as hard conglomerates or genuine rock were probably to be found in the soil. Future experience has shown that construction of marginal wharves on the sloping sea bed was very costly too. In the port expert's opinion it would have been worth-while to investigate more closely the nature of the subsoil on the site of the proposed inland basin before dismissing the only possibility of building a fully protected port. He also considered that the cost of dredging might have been fully offset by considerably lower construction costs of quay walls on land, around the inland basin.

After having studied and discussed the relative advantages of the two alternative sites for open marginal wharves, near the Lighter Basin and south of the village, the Aqaba Port Authority and the Jordan Development Board decided, late in 1953, in favour of the site originally selected by the U.N. port expert, on the vast empty plain south of the village. The area close to the Military Basin, in addition to its unfavourable location, fully exposed to the southern storms, did not offer enough space on land for various port facilities. Moreover, phosphate dust would have been blown by the prevailing winds right into the centre of the inhabited area and the main part of the village would have been cut off from the sea.

Fig. 4. General view of the deep-water Port area.

The port authority also shared the United Nations' expert's opinion that it is much more reasonable to build, in the first place a deep water berth for general cargo, rather than to be forced in the future to convert lighter wharves into deep water wharves, when imports of general cargo increase as they were expected to increase in a young and rapidly expanding economy.

In 1955, the consultants' point of view with respect to the general cargo berth received a strong backing from a special Mission of the International Bank for Reconstruction and Development, which carried out a general survey of economic conditions in Jordan. The Mission thought that Beirut, as an old and well established port would keep about 50% of Jordan's imports and that, beginning with 1958, a more or less steady import traffic of 130,000 to 135,000 tons per year would establish itself in Aqaba; part of it would come on small coastal vessels with cargoes transhipped in Suez and Port Said. The Mission advised therefore, for economic reasons, against building a deep water berth for general cargo, and supported the consultants' recommendation for building a lighter wharf instead. On the other hand the Mission approved the choice of the port site south of the village, and the construction of a high-speed phosphate loading plant at a deep water berth.

At the same time the consulting engineers advised that construction costs would be considerably higher than estimated in 1953, mainly because of the deep slope of the loose sandy bed, and that a much higher saving than anticipated, in the order of say £300,000, could be made by building for general cargo a lighter wharf instead of a deep water wharf.

The entire problem had to be rediscussed by all interested parties, including the International Bank Mission, and an increase of credits had to be requested from British Development Loans. The Aqaba Port Authority and the U.N. port expert believed that prospects for general cargo imports via Aqaba were much brighter than the Mission's estimates. In view of obvious economic advantages of direct unloading of ships, a possible saving of £300,000 would not be justified when the Port Scheme was considered as part of an overall scheme, amounting to many millions of pounds, which included not only the port works, but the building of a road from Aqaba to Amman and the modernisation of the railway. High officials in charge of British Development loans shared this view.

The Development Board confirmed therefore the previous decision to build one deep water berth for general cargo and another for phosphates. In December 155, additional credits were approved for the project to meet the increased building costs.

(To be continued)

Increased Trade at Melbourne

The continuing growth of population and industry throughout Victoria is reflected in the big increase in shipping and in the volume of traffic handled at the Port of Melbourne in 1959. During the year the port handled a total of 8,843,836 tons of cargo—503,000 tons more than in 1958 and the second highest total in 10 years.

Imports totalled 6,431,129 tons, the principal commodities being bulk oils, paper, chemicals and pyrites. Exports amounted to 2,412,707 tons, chiefly comprising wool, flour, fruit, meat and dairy produce.

A total of 2,751 ships used the port, an increase of 119. The figure includes vessels of the new shipping services which have been opened between Australia and other countries during the past twelve months.

Latex-Cement Road Surfacings

New Composition for Heavy Dock Traffic*

By E. G. RAWLINGS
(Technical Adviser, Industrial Division, Semtex Ltd.)

During recent years road surfacing compounds containing rubber have received considerable publicity and these " rubberized roads " are now widely used throughout the world. At the same time, however, rubber—in a different form—is playing an increasingly important role in the formulation of specialized road surfacings.

Basically the " rubberized roads " comprise an asphaltic surfacing compound to which natural rubber is added in powder form prior to laying. In the case of the more recent development, however, natural rubber latex is used as the binding medium for the whole composition and the materials are based on the rubber latex-hydraulic cement technique. Compositions of this type have been used for many years as monolithic floor surfacings, and as corrosion-resistant mortars, etc., but modern trends in the design of bridges have placed demands upon the final surfacing material which are met by the properties of these latex-cement compounds.

Steel Deck Bridges

In the case of all steel bridges or bridges having steel decks certain requirements are made of the surfacing compound, namely:

(a) The material should be as lightweight as possible, since a heavy surfacing will demand the use of more structural steelwork, leading to cost increases in terms of both materials and labour.

(b) The surfacing should protect the basic steel plate from corrosion.

(c) Excellent adhesion to the steel is necessary especially in the case of bascule and swing bridges.

(d) Flexibility is a further requirement of the surfacing in order that it may withstand movement of the bridge deck resulting from traffic, temperature changes, high winds and, in the case of lift and swing bridges, vibration whilst the bridge is in motion.

(e) In addition, the surfacing must, of course, possess good properties of abrasion resistance.

From the above points it will be evident that the conventional types of road surfacing compounds possess certain disadvantages for this type of work, namely they are not lightweight, do not adhere well to steel, and are not sufficiently flexible to withstand the degree of movement which is envisaged for this type of bridge.

The latex-cement compounds do, on the other hand, fulfil these various requirements and an investigation of their performance under working conditions was therefore suggested.

Fig. 1. A latex-cement surfacing being applied to the deck of a lift bridge in the London Docks.

Formulation of Latex-Cements

As stated previously, the latex-cements have been known for some years, and their composition and properties have been well publicized. It is not proposed therefore to cover this ground again in detail, but merely to summarize the properties which recommend the materials for bridge surfacing work.

Basically the latex-cements comprise mixtures of natural rubber latex, hydraulic cement of the Portland or high alumina types, suitable fillers, rubber vulcanizing agents and anti-oxidants. Experience has proved that the best properties are obtained with compounds having as high a rubber content as possible, and for road surfacings the formulae have been based on high alumina cement.

On the question of fillers, both sharp, clean granite chippings and clean, washed gravel were investigated for this particular application, and it was found that granite was the preferred material due to its angular and irregular shape. In the case of gravel fillers it was found that there was a tendency for the gravel to "pick" out of the compound on the surface and it was considered that this was due to the round shape of the particles.

When considered in conjunction with the requirements of the surfacing as listed above, the properties of the latex-cements

Fig. 2. The two spans of this lift bridge were surfaced in 1954 since when the latex-cement has satisfactorily withstood heavy dock traffic.

*Reproduced in collaboration with The Natural Rubber Development Board.

reveal the following points.

(a) *Weight.* The weight of a latex-cement surfacing is approximately 52 lb. per sq. yd. at $\frac{1}{2}$-in. thickness. Whilst in terms of the specific gravity of the materials there is little difference between these materials and asphalt, it would, of course, not be possible to lay an asphaltic surfacing at $\frac{1}{2}$-in. thickness on a steel deck. Thus the saving in weight is effected by reducing the thickness.

(b) *Corrosion resistance.* Latex-cement compositions have been used, for many years, on ships' weatherdecks and it has been proved that these materials protect the basic steelwork from corrosion.

(c) *Adhesion.* One of the most outstanding properties of the latex-cements is their excellent adhesion to a wide range of surfaces. In the case of steel the average adhesion is of the order of 700 lb. per sq. in. when measured by a direct pull-off test.

(d) *Flexibility.* The natural rubber content of the material imparts properties of flexibility and again this point has been demonstrated over a considerable period by the work carried out on ships' decks, where considerable movement of the deck is likely to occur, especially in heavy seas.

Investigation of Abrasion Resistance

The major unknown quantity in connection with the possible use of latex-cement compositions for road surfacing work was their resistance to abrasion. Whilst the materials had been widely used for land and marine flooring and decking work, the demands made upon the surfacing by wheeled traffic of all types and weights posed a new problem.

Fig. 3. This photograph was taken only 16 hours after completion of surfacing, and the vibration of the bridge in no way affected the latex-cement composition.

Tests were therefore carried out by the Road Research Station, Department of Scientific and Industrial Research, using an abrasion testing machine of their own design. Briefly the apparatus comprised a circular table on to which were mounted the samples under test. Rubber-tyred wheels which were loaded to a known degree were then caused to travel over the panels for a fixed period of time and at a known speed. The tests were also carried out under conditions of known temperature and humidity.

The conditions obtaining during the tests were then correlated with known road conditions and thus the degree of abrasion recorded could be compared with the known abrasion resistance of conventional surfacings.

The results obtained with the latex-cements indicated that the abrasion resistance was of a high order and compared very favourably with asphaltic surfacings.

Preliminary Road Tests

Following the results of the abrasion resistance tests, arrangements were made for a small area of latex-cement surfacing to be subjected to a road trial, and the material was laid at $\frac{1}{2}$-in. thickness on a $\frac{3}{8}$-in. thickness steel plate which was subsequently let into the A.4 London-to-Bath road at Harmondsworth, Middlesex.

The conditions obtaining on this particular section of road when the trial began in 1950 were:

	Tons
Average number of vehicles per 24 hr. ...	8,000
Average total load per 24 hr.	30,000

These figures are, of course, only approximate and variations will occur at weekends, holiday periods, etc. At the same time, however, the data do provide an indication of the conditions of test.

The trial was continued for approximately 5½ years and the performance of the surfacing was outstandingly good. Fig. 4 gives an impression of the condition of the surfacing after three years of test. It is of interest to note that, whilst the original intention was to fix the test panel in the road mechanically, this technique was in fact never used and during the whole test period the plate lay loose in a recess cut into the existing road surface. This resulted in the plate "jumping" under heavy traffic, but this excessive movement did not give rise to any loss of adhesion. In addition the joint around the perimeter of the panel filled with water during wet weather and, whilst there was a very slight tendency for edge attack to occur at the latex-cement/steel interface, this would not be so on bridges, as the edges would be sealed.

Whilst the test panel was located in an

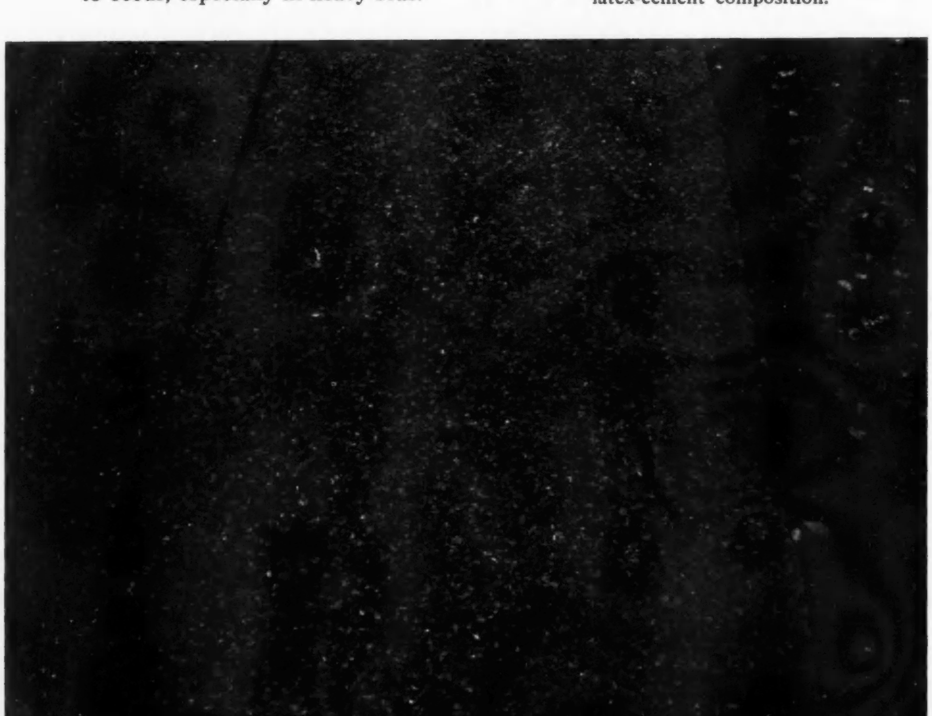


Fig. 4. Close-up of latex-cement road surfacing after three years' exposure to traffic in the A.4 London-Bath road.

open stretch of road and was not therefore subjected to a great deal of braking or starting, there was evidence to suggest that the skid resistance of the latex-cement surfacing was above average.

Bridge Trials

The first full-scale bridge surfacing trial was carried out for the Port of London Authority on a small lift bridge (total area approximately 70 sq. yd.) in the London Docks during 1954. The bridge in question was of timber deck construction and in consequence the technique of laying the latex-cement surfacing had to be modified, insofar as it was necessary to include reinforcement in the form of welded steel mesh of approximately 2-in. mesh. The object of this reinforcement was to accommodate the differential movement of the timbers and it would not be necessary on a steel deck.

At this stage it may be opportune to discuss the laying techniques employed in applying latex-cement surfacings, since these differ considerably from conventional road surfacing practice.

In the case of steel decks the metal is first cleaned by either shot blasting or mechanical wire brushing to remove all rust, mill-scale, etc. A priming coat of latex-cement containing a fine filler is then applied at approximately 1/32-in. thickness. The object of this priming is both to secure the maximum adhesion to the steel, and to quickly cover the freshly cleaned metal, thus preventing further corrosion.

The surfacing compound is then mixed—either by hand or by machine—and applied at the required thickness by spreading with a trowel. The thickness used will depend mainly upon the traffic conditions, but will be of the order of $\frac{3}{8}$-in. to $\frac{1}{2}$-in. The composition takes on its initial set quite rapidly, and is ready to receive foot traffic after approximately 12 hours. The usual recommendation is, however, that the surfacing should not be opened to wheeled traffic for three to four days after laying.

In the case of the London Docks lift bridge, the timber deck was primed and the steel mesh was then set in a second priming coat. The surfacing was then applied in the usual way. Fig. 1 shows the application technique for the surfacing, and the steel mesh embedded in the primer.

This area has also been successful and the bridge is still in use. It is of interest to note that it was necessary to open the bridge only 16 hours after completion of surfacing and there was no tendency towards loss of adhesion resulting from the movement and vibration involved (Figs. 2 and 3).

Following this contract a swing bridge was surfaced in Yorkshire, again a timber deck was involved. In this case, however, steel plates were embedded on to the existing timber with latex-cement and subsequently bolted down. The surface was then treated as a new bridge.

A further contract was carried out in 1956 on a steel bridge deck in Iraq over the River Euphrates and a recent report has stated that this surfacing is quite satisfactory

Test in Germany

A good deal of both experimental and contract work has been carried out with these materials in Germany where the bridge-building programme is heavy. The following are the results of some recent tests there.

(a) **Rolling Tests**

At high summer temperatures, bridge coverings often tend to soften and, as a result of the traffic conditions, they become wavy and undulated. Latex-cement coverings were subjected to a rolling pressure of 200 lb. per sq. in. at a temperature of 60°C. and it was found that they did not deform.

(b) **Vibration**

For these tests an amplitude of 3.5 mm. was used and the latex-cement compositions were firstly subjected to 2,263,650 vibrations at a frequency of 10 cycles per sec. and at temperatures between 18°C. and 25°C.

In order to assess the performance at low temperatures the material was vibrated 4,000 times at 4 cycles per sec. and at −32°C., followed by 10,000 vibrations at 10 cycles per sec. at the same temperature.

These tests are in excess of the German requirements, but there was no tendency for the surfacing to crack or lose adhesion.

Cost of Surfaces

Despite the fact that these materials are only laid at approximately $\frac{1}{2}$-in. thickness they are definitely more expensive than asphaltic surfacings, the cost being of the order of 50s. per sq. yd., laid. At the same time the compositions do fulfil a specialist requirement.

It is, however, envisaged that this order of cost would rule out the use of latex-cement surfacings on general roadways and that they will find their greatest application on bridges where the increased cost is warranted by the improvement in properties and performance which are obtained.

Conclusion

It will be evident from the foregoing that natural rubber has found yet another application and, whilst it cannot be stated that the technique of using rubber in roads is by any means new, it is fair to say that the use of latex-cement compositions for this work is revolutionary.

Considerable interest has already been shown in the technique and enquiries for latex-cement bridge deckings have been received from as far afield as India and Western Canada.

Dry Dock for Eastern Japan

Modern Design Incorporating New Techniques

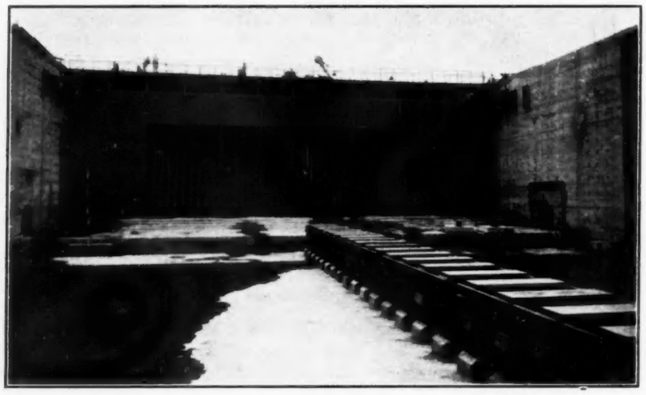
As the Keihin district near Tokyo is the centre of the steel and petroleum industries in eastern Japan and contains almost 30 per cent of the nation's oil refining installations, there has been a rapid increase in the number of large tankers and ore carriers calling at the neighbouring ports. This in turn has created a demand for further and larger dry docks in the area for building and repairing facilities. Recently a new dry dock capable of accommodating vessels up to 40,000 tons deadweight was completed at the Kanagawa shipyard of Hitachi Zosen in the Port of Kawasaki which is midway between Tokyo and Yokohama.

The dry dock is modern in design and incorporates all the latest facilities in use in other new dry docks throughout the world. It also includes certain innovations which are the result of the Company's own research. The length of the dock from gate to head is 721-ft. 10-in., and width 98-ft. 5-in. The depth at the dock entrance is 32-ft. 10-in. Special features of the dock include a flap-type dock gate, automatically adjustable bilge blocks, the use of electric trucks for docking and undocking, highly efficient pumping equipment and a service tunnel. As an auxiliary facility, it is intended to instal equipment for disposing of oil sludge and so facilitate the speedy and economic cleaning of ships' tanks.

This new dock lies facing the Keihin Canal on the southern side of an old dry dock capable of accommodating ships of up to 10,000 d.w.t. Except for a platform 1 m. in width running round the dock near the top, the perpendicular walls are sheer to the bottom. Two sets of handrails are provided for safety, one guarding the platform, the other the top of the dock wall. In constructing the wall, sheet piles were first driven into the ground and then finished with ferro-concrete. The economy of time in construction of this building method has been proved, and enabled this dock to be completed in just over a year.

The dock gate is a single-plate flap-gate provided with an air

chamber, which is the most important feature of the dock. The gate, which is hinged to the bottom of the dock entrance, is operated by electric winches, and can be opened or closed in about five minutes. The air chamber facilitates this operation.



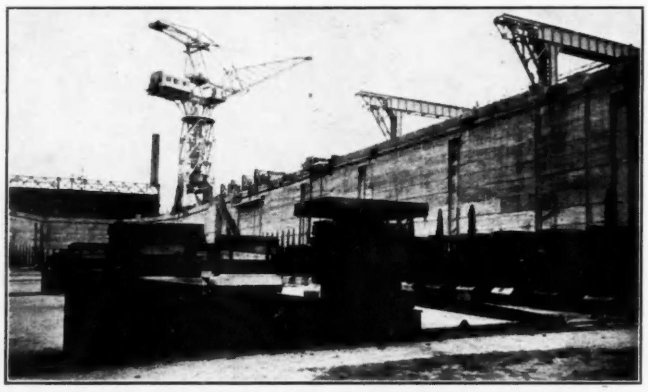
The dock gate.

Filling the dock is effected by specially designed cylindrical valves each 1.5 m. in diameter with ducts installed in the walls on each side of the entrance. These valves are easy to operate and the dock can be filled in 1½ hours.

Draining is carried out by two main drainage pumps of 400 h.p. with a capacity of 150 cu. m. per hr., and two auxiliary pumps of 40 h.p. with a capacity of 9 cu. m. per hr. These are installed in the pump room inside the dock wall at the entrance. Draining is completed in 2½ hrs. at high tide and in 2 hrs. at other times.

Docking Operation

In docking, the vessel is first led in by winches positioned on each side of the entrance, and then by two electric trucks running on rails on each side of the dock. The whole operation takes about 15 minutes. This method is similar to that employed



Fixed bilge block and automatically adjustable bilge block.

at the Panama Canal and is the first instance of its use in Japan. It is expected to effect a considerable economy in time and labour.

In addition to the conventional keel and bilge blocks, the dock is fitted with eleven sets of wedge-shaped automatically adjustable bilge blocks. As the ship settles on the keel blocks, these bilge blocks are hydraulically adjusted either singly or simultaneously to support the sides of the ship. This obviates the need for the conventional shoring and therefore considerably shortens docking time. Each of these bilge blocks is able to stand a load of 200 tons.

A concrete service tunnel, 2.2 m. in height and 1.8 m. in width, is contained in the upper part of the dock wall. This accommodates the various pipelines and cables necessary such as sea and fresh water lines, compressed air, oxygen and acetylene gas lines, electric cables for direct current (100, 200 volts) and alternating current (100, 200, 440 volts each in 50 and 60 cycles).

The dock is equipped with a 25-ton travelling level-luffing crane on its righthand shore. This crane operates within a maximum radius of 36 m.

There are two concrete staircases, one on each side of the dock, which lead down to the bottom. Light fittings for work at the dock bottom are installed on the wall close to the floor of the dock.

Supplementary Facilities

Oily Water Separation.—Equipment for separating oil sludge taken out of a ship's oil tanks at the time of cleaning is to be provided in the vicinity of the mooring quay. This will consist of a storage tank with a capacity of 2,000 tons for containing the sludge, three "Autosep" Coastguard Separators each with a

View of the completed dock.

capacity of 100 t/hr and two 160-ton storage tanks for holding the separated oil. Pipelines will connect the installation to the moored ship.

Until this facility has been completed for use, a barge is being used to collect the sludge and this is capable of carrying some 300 tons of oil. A dumping ground is provided for the disposal of the oil sludge.

Tug Fleet.—In addition to three tugs already in service, the "Kanagawa Maru" was built by the Company for special duties in the dock. This tug, 26 m. in length by 7.4 m. wide, is equipped with controllable pitch propellers and two 600 b.h.p. diesel engines. It is 178 g.t. and has a speed of 12.25 knots.

Mooring Quay.—A mooring quay on the eastern side of the yard is capable of accommodating four vessels with a tonnage of some 70,000 d.w.

The company of Hitachi Zosen have a long history as shipbuilders since their establishment in 1881 in Osaka City. Besides the Kanagawa Shipyard, they control the Sakurajima and Chikko Shipyards in Osaka and the Innoshima and Mukaishima Shipyards in Hiroshima Prefecture. In addition to building, reconstructing and repairing ships, they manufacture marine diesel engines, marine machinery, industrial machinery and steel structures. At the five shipyards there are 11 building berths, the largest being capable of accommodating ships of up to 65,000 tons; 13 dry docks including the 40,000 dwt. capacity Kanagawa dock; a large welding shop and an engine assembly shop.

Marine Terminal at Milford Haven

New Installation for Oil Handling

(Specially Contributed)

Several highly interesting and unusual civil engineering features have been incorporated in the construction of the new marine terminal at Milford Haven, Pembrokeshire, a brief description of which appeared in the November 1959 issue of this Journal. The terminal is capable of handling super tankers having a deadweight of over 100,000 tons and has been equipped for dealing with both crude and finished oil products in connection with the large refinery being erected in the vicinity by Messrs. Foster Wheeler Limited, for the Esso Petroleum Company Limited.

The entire civil works of the marine terminal scheme was planned and carried out by John Mowlem and Co. Ltd., 91 Ebury Bridge Road, London, and emphasis was laid at the design stage in pre-casting units on shore for subsequent assembly in position rather than constructing insitu with all the attendant difficulties of erecting shuttering, installing reinforcement steel and handling concrete materials over the water.

The works comprise an approach jetty 3,500-ft. long carrying a 16-ft. roadway leading to a tee head 1,000-ft. in length, at each end of which is a 350-ft. by 50-ft. berth for the new super-tankers. There are 13 dolphins carrying bollards for mooring purposes, the largest of these having a deck 50-ft. by 35-ft. with a slab thickness of 7-ft.

Each bay of the main approach superstructure consists basically of a lower trestle unit resting on two piles, an upper trestle unit and two road slabs, all being formed into a monolithic structure with insitu concrete. The kerbing was cast in-situ. The road slabs are 35-ft. long and 8-ft. wide, two slabs forming the width of the roadway. The total pipe-band width is 45-ft.

The precast units weighed up to 18 tons each and were placed by an 18-ton self-propelled floating crane or by a 20-ton, 120-ft. jib steam derrick. The insitu concrete was mixed in 100-ton barges and placed by floating crane.

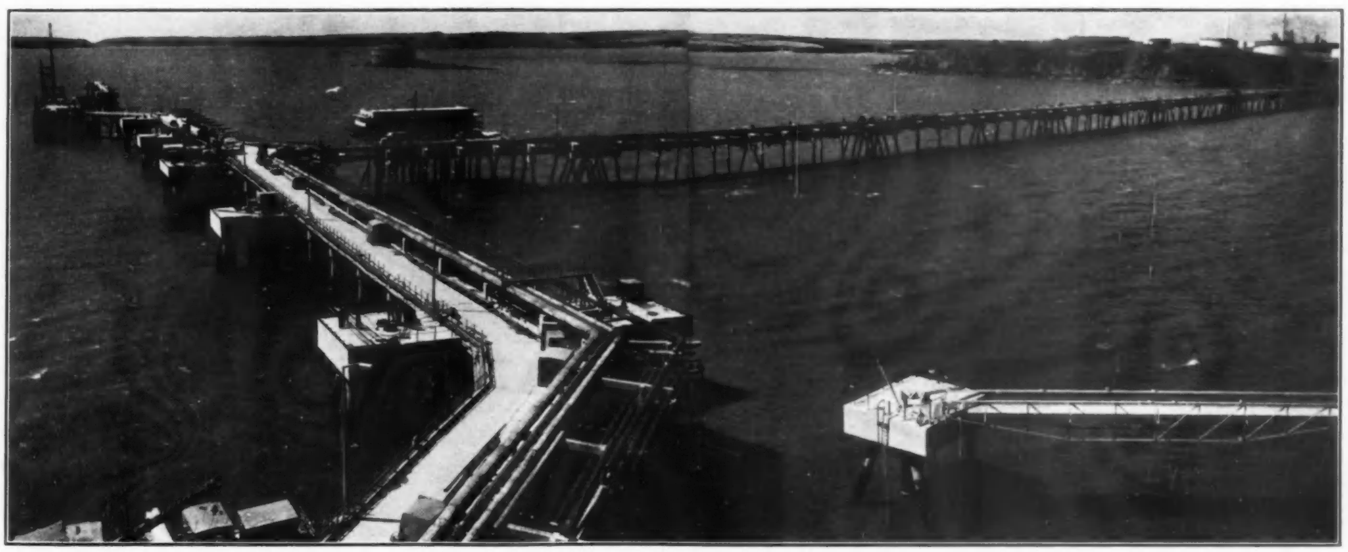
To avoid heavy and costly soffit shuttering in the construction of the berths and dolphins, a system of precast soffit slabs was adopted. These are strengthened with light fabricated steel trusses which are subsequently incorporated in the reinforcement of the superstructure.

The casting bed for both precast units and piles was situated on high ground half a mile inland and extended over an area of 700-ft. by 250-ft.

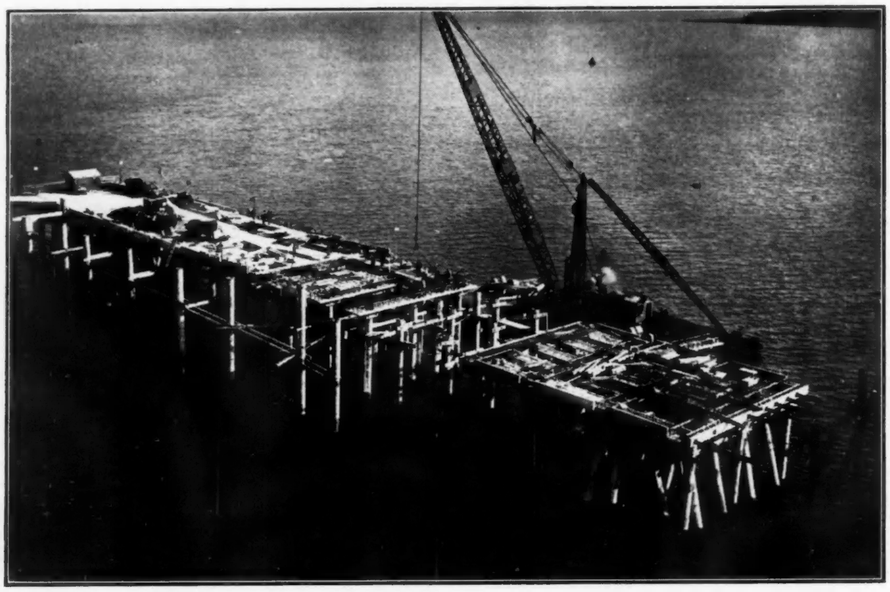
The hollow-core prestressed concrete piles, a number of which are over 140-ft. in length are believed to be the longest made of this type and are 22-in. and 27½-in. external diameter. They were driven by 8-ton and 10-ton semi-automatic steam hammers in 95-ft. raking frames mounted on ex-Naval Tank landing craft. It is believed that the 10-ton hammer supplied by The British Steel Piling Co., 10 Haymarket, London is the largest made in Britain and the same is thought to be true of the 15-ton piling winches manufactured by Henry Sykes Ltd., Southwark Street, London.

The hollow pre-stressed pile has great advantages over other types in that it combines lightness in handling with maximum economy of material and virtual freedom from cracking. The pile bed at Milford Haven was 500-ft. long and contained five pile soffits, which were mounted on rubber blocks.

M.V. "Grosvenor" driving a 130-ft. long, 27½-in. dia. prestressed concrete pile on Berth 2 with a 10-ton semi-automatic hammer. 95-ft. B.S.P. frame with pendulum leaders raked back at 1 in 3 over ship.



General view of Tee head and Approach Jetty taken from Hose Handling Structure. The second Berth for 100,000-ton tankers in background on left with its hose handling structure in course of erection.



Berth 1. Derrick pontoon "Cork" placing precast soffit box in position on piles.

Prestressing of the piles was carried out on the 'long line' system by which the concrete was cast around tensioned wires, and when the requisite strength had been reached (4,500 lb./sq. in.) the wire was detensioned. The pre-stress forces were thus transferred to the concrete and after burning off the projecting wire ends, the piles were lifted from the bed and placed in the stacking area.

High tensile wire 0.276-in. diameter was used for the longitudinal pile reinforcement. The wires were tensioned in groups of 20 by means of a 120-ton hydraulic jack which had a stroke of 4-ft. 6-in.

The formation of the core for the pile is unusual. Wires similar to those used for the pre-stressing but of 0.20-in. diameter were run the length of the bed. They were arranged uniformly around circular concrete spacers and when Sisalcraft paper was wound in a spiral fashion along the length of the wires a core of the required diameter was obtained. These wires, after destressing, were extracted and then laid out again for the next pile bed. The basic principle of forming hollow cores in this fashion is one for which Patent No. 800542 has been granted to Dow-Mac (Products) Limited, 18 Queen Street, London.

The concrete mix employed for casting piles was 1; 1¼; 2½ a water/cement ratio of 0.45. External vibrators were clamped transversely across the top of the moulds and moved along the line as casting proceeded. The concrete was discharged from skips which were handled by a travelling gantry spanning the bed.

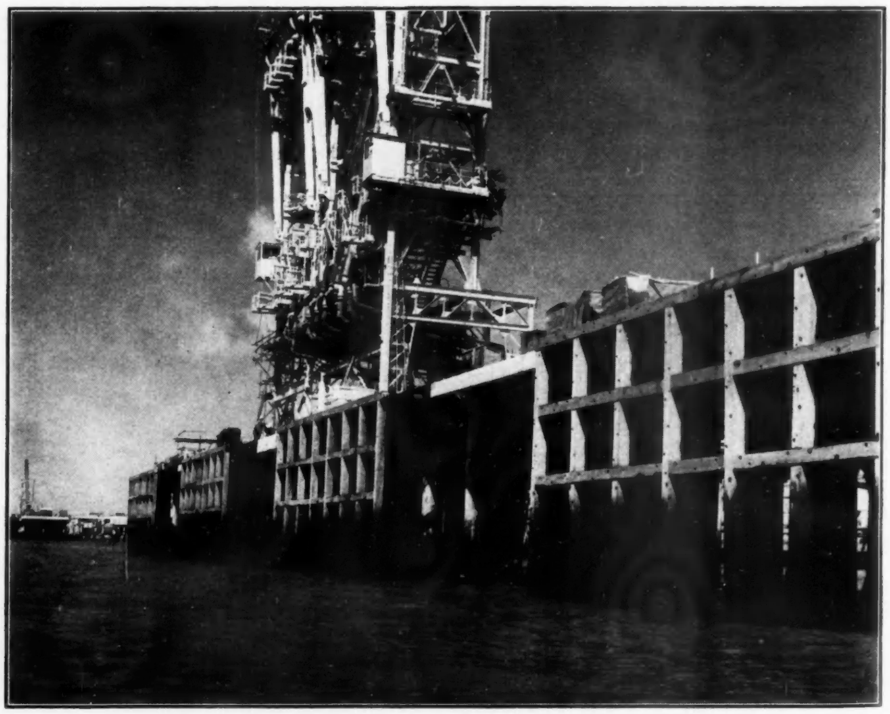
The piles were lifted and stacked after detensioning, generally within three days. Output of piling averaged about half a mile a week, the total quantity cast being something over 20 miles. After maturing, the piles were transported by a specially adapted 12-ton lorry with 15-ton trailer to a temporary jetty, about 1,500-ft. long, which was situated about 1 mile from the permanent jetty. From the end of the temporary jetty the piles were loaded by a 20-ton electric derrick on to pontoons which were towed to the driving site. Other precast units were handled in a similar manner.

Fendering System

The fenders are designed for vessels up to 125,000 tons displacement approaching at 10° at a speed of one knot with a mass factor of 0.5. Each main berth has four 52-ft. wide fenders which consist of eight 36-in. x 12-in. broad flange beam piles and walings, the latter being welded in situ to the piles. For the rubbing face 12-in. x 12-in. greenheart timbers are bolted to the outer flanges of the piles and walings.

To absorb impact shocks, 25-ton spring buffers by George Turton Platts and Co. Ltd., Bush Lane House, Cannon Street, London are employed. These buffers are 52¼-in. long overall, the diameter of the head being 16¾-in. The stroke is 16-in. In all, 48 buffers have been supplied for the scheme.

The bollard which has been adopted is of considerable interest and is thought to offer wide possibilities in all situations where special precautions have to be taken against fire and other risks. It is a new type of bollard with an ingenious quick-release mechanism which enables a ship to be immediately released from its moorings should any untoward eventuality arise. It has been designed by E. J. Bean Limited, 32 Victoria Street, London, and in view of its potentialities, fuller details are given on a following page.



First completed Berth for 100,000-ton tankers, with second Berth in distance (left). This view shows the completed Hose Handling Structure and the fendering system consisting of 36-in. x 12-in. B.F.B. piles and walings faced with 12-in. x 12-in. greenheart.

Development of the Modern Bollard

In the early centuries men moored their ships to rigid protuberances on the shore, such as living trees or rock formations and, where these were not available they used substitutes in the form of strong wooden stakes driven into the ground or pillars of stone.

As the size of ships increased, however, moorings of a more robust construction became necessary and metal, generally cast iron, was used in the form of pillars either embedded in concrete or fastened with bolts to the quay. These moorings had also to be shaped in various ways to prevent the ropes slipping off, for the larger ships varied considerably in height in relation to the water level. One form included the fitting of a cross bar and so increasing the top diameter of the mooring.

The advent of mechanically propelled vessels necessitated warping and checking on the bollard and this required a modification of the shape and design of the top, resulting in the twin pillar or bitt.

A modern device is the static Bean bollard which has been designed to fulfil both these requirements. It consists of two raking horns on the top of the column, primarily for use in checking and warping, and two horizontal horns shaped in the form of large lobes (see Fig. 1). These latter give a very long

Fig. 1

rope path on the bollard and, when the ropes from two ships are placed on these lobes, it is possible to release the moorings of one vessel without disturbing the other. It also is possible to moor a third vessel or craft on the horns. This is a considerable advantage where ships are moored in line and because of the shape of the bollard it is impossible for the moorings to slip off even when snatch or slackening take place.

Quick Release Bollard

During the last twenty years there has been a considerable increase in the amount of inflammable and dangerous materials, such as oil and chemicals, which is transported over the seas of the world and attention has been directed to the danger of fire to ships in port or at moorings and to the need, should occasion arise, to quickly cast off large ships moored with steel cables. To effect this quick release, a bollard has now been designed which incorporates a number of novel features.

The stem of this bollard, the base of which is fastened to the dolphin or berth in the normal manner (Fig. 2) carries a platform which is free to rotate about a vertical axis of sufficient size to withstand the maximum loading from any direction. The platform has horizontal trunnions mounted symmetrically on the column vertical centre. The head sheave is carried symmetrically on these trunnions and is free to rotate on their axis 45° above and below the horizontal centre of the trunnion. It is practically in balance with slight bias to the front of the column and locked automatically in the horizontal position when being loaded or when not in use.

The bight of the mooring rope noose is accommodated on a part sheave and the legs of the noose on two 'U' fittings in line

Fig. 2

with the centre of the sheave so that the legs of the noose are spread slightly. These 'U' fittings are pivoted below the centre line of the pull and are held apart by a simple latch.

At the bight end of the sheave there is a latch which is released by pressure of the rope pull, allowing the sheave to take up the required angle from the horizontal. Movement of the sheave around the vertical column of the bollard is not constrained at any time and the sheave automatically adjusts itself to the direction of the pull.

The release mechanism for the latch controlling the 'U' fittings is connected through the centre of the column to any desired control point which should be housed so that it cannot be interferred with by unauthorised persons. No springs are incorporated in the mechanism which can be operated mechanically, hydraulically, pneumatically or electrically, and can be arranged to release units separately or by a central manual which can be situated on the ship, on the quay, or on both. The sketch (Fig. 3) shows the hand trip mechanism.

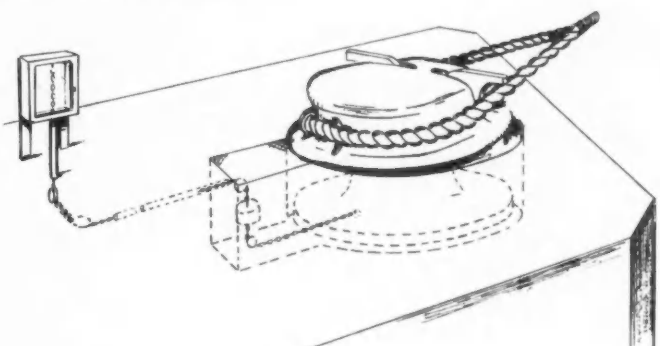


Fig. 3

When the latch is tripped the 'U' fittings pivot about their centres by the closing pressure exerted by the legs of the noose. The pull of the rope is thus thrown off the line of the trunnion and bight, causing the sheave to revolve in the vertical plane and cast the rope. After the rope has been cast, the sheave automatically resets in a horizontal position and the 'U' fittings are reset and latched.

Minerals Handling at Lobito

Description of New Mechanical Ore Loader

By R. C. HODGES
Engineer, Spencer (Melksham) Ltd.

THE urge of modern conditions and the need to speed up the movement of all manufactured or raw materials has necessitated the acquisition by the Portuguese of up-to-date equipment in the form of a new mechanical handling plant at the Port of Lobito, Angola, West Africa, to facilitate the reception, storage and outloading to ships of mineral ores received from Rhodesia and Central Africa via the Benguela Railway. The ores are iron ore, manganese ores and small quantities of zinc concentrates.

Storage area is arranged in eight heaps, each separate variety being allocated to one of these heaps, and is sited well back from the quay alongside which vessels are moored to receive their cargo of mineral. The plant may be divided into three sections, (1) unloading railway wagons; (2) storage of minerals; and (3) loading out to ships. Material arrives in bogie wagons of 41 tons maximum capacity, some of which are fitted with a brake cab. The wagons are overturned by a wagon tippler —specially designed for the accommodation of wagons with a brake cab—and the contents are deposited into concrete hopper suitably lined to minimize the damage that might occur from the impact of falling lumps of the ore.

The hopper is constructed in two sections and the elongated outlet of each is provided with a plate feeder for the extraction of the mineral which is fed to a short belt conveyor about 98-ft. 6-in. centres, rising from the pit underneath the hopper to the surface at the tail end of the store conveyor. The store conveyor, about 994-ft. centres, is transversely bridged by a wing conveyor structure arranged to travel to and fro longitudinally over it. Conveyor belt of the store conveyor is in one continuous length gradually rising in the trailing structure of the wing tripper to feed a reversible belt carried over each wing of the tripper delivering to a position of 58-ft. outreach to the storage area on either side. The wing tripper, wagon tippler, feeders and intermediate conveyors form the unloading and intake section capable of handling at the rate of 240 tons per hour to the store.

Between the wing tripper and the delivery end of the store conveyor two grabbing cranes and a receiving hopper, each with structures bridging over the store conveyor, can travel longitudinally and reclaim material from the store for loading out to ship at the rate of 400 tons per hour. This operation may be carried out simultaneously with that of intake from railway wagons to store. Material grabbed from the storage area is discharged into the travelling hopper mounted between the two cranes and shunted to the required position by the latter. Material is extracted from the hopper by a plate feeder and fed to the main belt, the delivery point being especially designed and arranged to minimize any damage that may occur from the transfer of lump material to the belt of the store conveyor.

Material delivered from the store conveyor is fed to another conveyor about 215-ft. centres inclined and at right angles; this conveyor is combined with a continuous weigher, the whole being carried on braced steel girders supported by a junction tower at each end and two intermediate supporting trestles. This equipment is followed by a quayside conveyor about 500-ft. centres fitted with a travelling throw-off, the whole being carried by six spans of braced steel girders supported by a junction tower at each end and five intermediate trestles.

The plant terminates with an outloader on the quayside, consisting of a conveyor carried in a hinged boom supported and adjusted by steel wire ropes from a tower incorporated with a steel-framed portal structure. This structure travels on two steel track rails arranged at 8.5 m. (about 28-ft.) centres along the quay surface. The boom can be adjusted to suit the requirements of vessels to be loaded and can be housed to give vertical clearance above the quay edge. The operator's cabin is well up on the tower to give a clear view into the hold of the ship during loading operations.

Outloader receives its feed from the movable throw-off fitted to the quayside conveyor, the outloader and throw-off being directly coupled to ensure that the two travel together. The conveyor belts are of rubber and canvas 42-in. wide, running at about 265-ft. per min.

Briefly the important features of the main items of the plant, each of which is provided with electrical equipment designed to suit tropical conditions and a current supply of 380 volts 3 phase 50 cycles, are as follows:

Wagon Tippler

The design of the tippler and its driving gear renders it suitable for dealing with the heaviest wagon assumed to have a tare weight of 18,600 kgs. (about 18 tons), carrying a payload of 42,000 kgs. (about 41 tons), thus giving a gross weight of 60,000 kgs. (about 59 tons). The maximum length of wagon body catered for is 13.85 m. (45-ft. 6-in.) and width of 2.42 m. (8-ft.). The tippler is designed to handle 10 wagons per hour, average content being 24 tons per wagon. The speed is such that a complete cycle of operations required for each truck takes six minutes including one minute for changing wagons. It has a pivoted rail table carried in a long twin-armed cradle fitted with trunnions fixed on a low concrete wall forming the ends of the hopper. The cradle arms are about 52-ft. centres lifted and rotated by means of a pair of steel wire ropes carried over head pulleys on a steel overhead framework and operated by means of a reversible winding gear fixed to the foundations at the back of the tippler. The wagon is held in its inverted position by means of a series of retaining beams spaced at intervals to support the body of the wagon.

The winch is operated by a 90 b.h.p. slip-ring motor, equipped with an electro-hydraulic automatic post brake (which will hold the cradle in any position), and a totally enclosed oil-bath worm reduction gear. This is followed by two sets of machine-cut spur gears in oil-bath steel gear cases with countershafts carried in self-aligning bronze alloy bushed pedestals driving a 4-ft. diameter cast iron machine-grooved winding drum and screw-driven limit switch.

Grabbing Cranes

Two cranes required for reclaiming from the store have a lifting capacity of 10 tons and are portable electric grabbing cranes fitted with level luffing gear and crank-operated balanced jibs. The motions of hoisting, luffing, travelling and slewing are operated by separate motors. Revolving superstructures are carried on a live ring of steel tapered rollers, the hoisting gears are of the twin winch type, one holding and one closing, each with its own motor. Trucks, which are of portal construction to bridge over the store conveyor, are mounted on 8 flanged rail wheels—two under each truck corner in compensating carriages.

Each crane is provided with a four-rope grab of 1.9/1.55-cu. m. (67/54 cu. ft.) capacity, the jaws of which are fitted with detachable manganese teeth. With a 10-ton load the speeds are: hoisting 46 m. per min.; slewing 1 rev. per min.; luffing 36 m. per min.; and travelling 12 m. per min. The cranes are capable of an hourly output of 240 tons assuming the grab to be filled at every lift and on the basis of an average cycle consisting of closing grab, hoisting 3 m., luffing 12 m., slewing .25 rev., discharge and return.

Crank luffing gear has the advantage that

no ropes are required for holding the jib, which is balanced at all radii and under all conditions from no load to maximum load. It is in a state of equilibrium at any radius. The machinery and driver's cabin is made of timber with louvres for ventilation and a double roof for working in a tropical climate. Controllers and levers are grouped in a convenient manner at the front of the cabin and arranged so as to be within the easy control of one man sitting in such a position as to have a good view of the load and area he is working. The master controllers are provided for the close and hold motors for the grab and are coupled to unilever gear giving control of both motors on a single handle.

The electric supply is picked up at fixed points along the store by a flexible cable reeled on a counterweight-operated radial cable reeling drum fitted to the crane truck and accommodating about 120-ft. of tough rubber-sheathed trailing cable.

Travelling Wing Tripper or Travelling Stacker

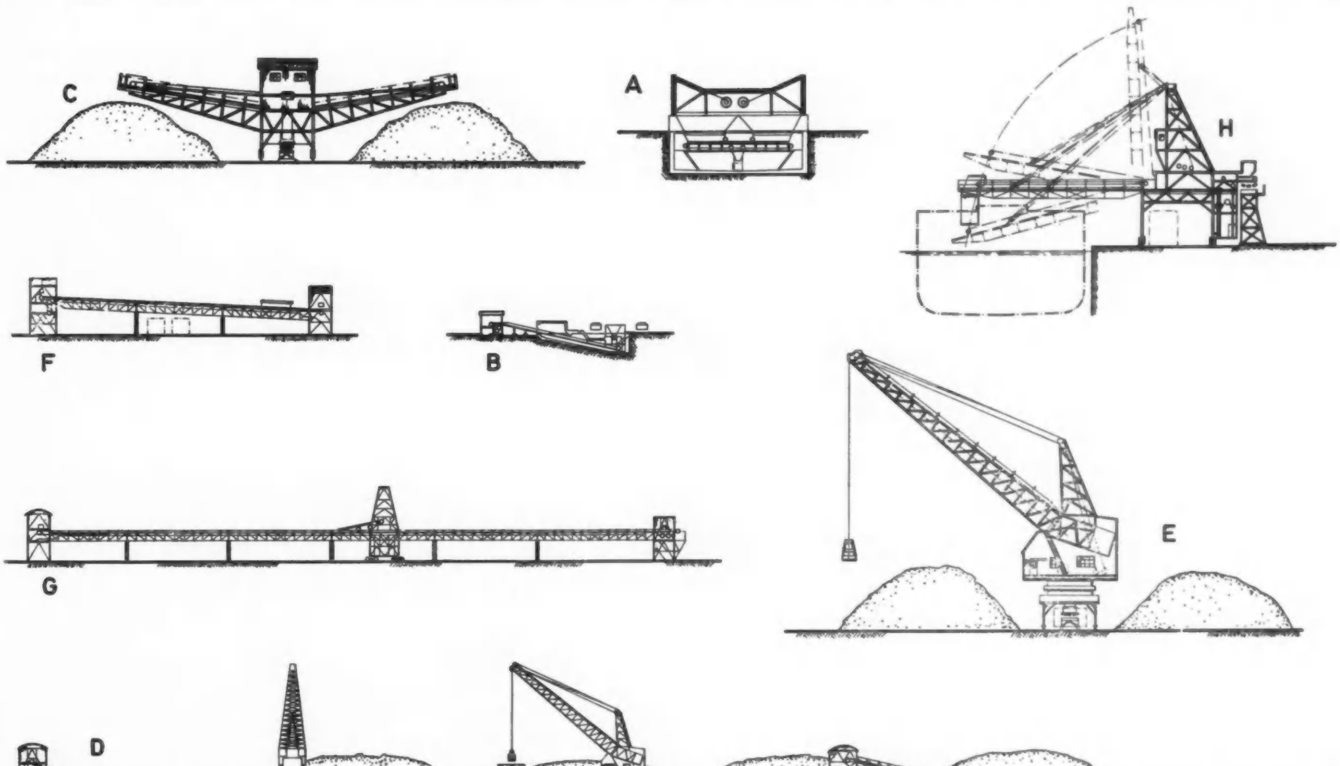
A travelling tripper in the form of a conventional throw-off, but of much greater dimensions, combined with a reversible transverse belt extending into the wings of the unit, is also provided for feeding to the storage and either side of the main store belt. The main store endless belt continues in a loop to the top pulley of the tripper where delivery is effected to the transverse conveyor, the mineral falling from the terminal of either wing as required to fill the storage area beneath.

The steel structure forming this unit is built up of rolled steel sections suitably braced to form a portal frame for spanning the store conveyor and provided also with travelling wheels for running on the crane rail tracks. It is formed with cantilevered braced steel frames on either side, at right angles to the main store conveyor supporting the rolls, pulleys and mechanical details of the reversible belt conveyor delivering to the store. An inclined braced girder with hinged connection to the main frame is supported at its lower end by a bogie frame fitted with two trailing wheels arranged to run on the crane tracks. The inclined girder also carries the troughing rolls for that section of the store conveyor. The main steel-frame tower is supported on two driven bogies each fitted with cast-steel double-flanged wheels, 24-in. diameter, and two single double-flanged wheels running on fixed axles.

Two sets of propelling gear are provided for driving one bogie on each track, with a synchronous motor for each mounted on an extension of the bogie frames, the drive being taken through worm and spur gear to the rail wheels, both of which are intercoupled with spur gears and intermediate idler pinion. Four pulleys, including the head terminal, are provided for the deflection of the store conveyor belt including also cage pulleys to assist in keeping the belt clean. The head terminal pulley is provided with a delivery hood and adjustable rubber sealing strips for feeding direct to the wing conveyor or belt.

Travelling Quayside Outloader

The quayside outloader is designed for easy adjustment and access to the hatches of the vessels using the mineral loading berth, and to give clearance of ships' rigging and other port equipment sited in the area of its operation. It is equipped with a hinged boom adjustable to suit laden vessels at low water and housed to permit the passage of cranes along the quay front as required. The loading-out conveyor, of 400 tons per hour capacity and about 65-ft. centres, is carried on this hinged boom with a fixed section 35-ft. centres, extending rearwards to the junction with the quay conveyor from which it receives its feed. The hinged boom can be adjusted from its



A. Wagon tippler. B. Conveyor section leading from wagon tippler to conveyor section D. C. Wing Tripper D. Conveyor section running past mineral ore stockpile. E. Giant grabbing crane for loading ore from stockpile to conveyor section. F. Conveyor section connecting C. to G. G. Quay conveyor section. H. Transporter for loading ore from conveyor system into ship's hold.

General view of the new Ore Handling Plant at Lobito.

lowest to its housed position in about $5\frac{1}{2}$ min. The driving pulley and weighted tightener for the boom conveyor are arranged outside the rear leg of the travelling structure.

At the hinge point closely pitched idlers having a flatter troughing angle are provided on the carrying structure adequately to support the belt on this point throughout its loading range. When housed, the belt contacts a deflecting roll fitted to the upper structure—the correct tension being maintained on the belt in all positions by the weighted tightener at the rear end. The return belt is also deflected by a roll fitted adjacent to the hinge point. The pulley at the end of the hinged boom delivering to the ship is fitted with a steel chute to which is attached a circular rubber and canvas spout deflecting the material into the hold of the vessel.

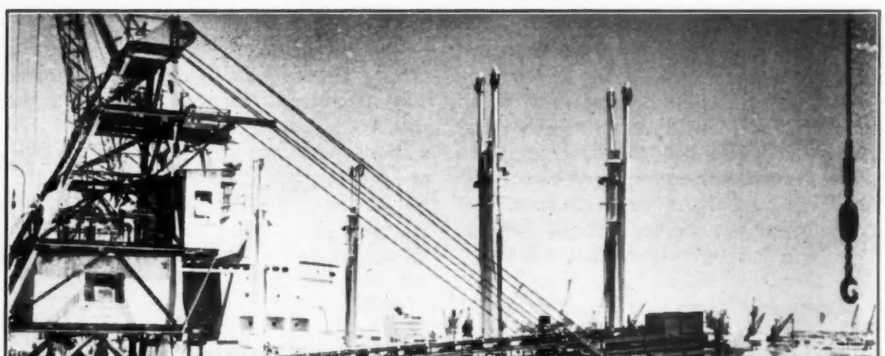
A short feeder conveyor is interposed between the throw-off from the quayside conveyor and the receiving point on the travelling outloader to minimize any belt damage that might occur at this transfer point from falling lump material, or choking that might occur through sluggish material holding up in a long chute. A suitable coupling is arranged between the outloader and the throw-off on the quayside conveyor to ensure that both move together when the outloader is adjusted on the quayside.

The outloader is travelled by two $7\frac{1}{2}$ h.p. synchronous motors each driving a two-rail wheeled bogie through a train of spur and worm gears, the motors being fitted with a solenoid brake. Trailing bogies arranged with two wheels are fitted at the opposite end of the structure. It is fully equipped with safety and limit switches so that when the boom moves out of its loading range the outloader conveyor motor becomes inoperative, also the boom hoisting gear will be cut out in the highest housed position and the lowest operating position—87 deg. above the horizontal and 18 deg. below. Should the boom sway, causing misalignment to the conveyor belt, the conveyor motor is stopped. Two slack rope switches are also provided in the boom hoisting motion. The boom is operated by two sets of three-fall ropes operated from two separate hoisting barrels.

Conveyors

The conveyor belts are of rubber and canvas 7-ply thick carried on 5-roll cast iron troughing idlers running in ball bearings arranged at about 4-ft. pitch. Rubber disc impact idlers are provided at feed points to minimize damage that may occur from falling lump material. Return idlers are of the horizontal spaced type each comprising a number of narrow cast iron rollers spaced apart on a steel spindle turned down on the ends for running in two self-aligning ballbearing brackets bolted to the underside of the stringers at about 12-ft. pitch.

The store conveyor, which is the longest, has an overall length of 2,064-ft. of belting including the section embracing the wing tripper. Apart from a small percentage variation the belts are arranged to run at an approximate speed of 265-ft. min. Stringers are of rolled steel sections in either angles or channels with sheet steel plating for bolting across the tops to protect the return belt. Terminal pulleys are of cast iron turned on the outside mounted on steel shafts running in self-aligning ball bearings. Drives from the respective motors are transmitted through worm and machine-cut spur



View of the travelling outloader in operation. This outloader is capable of loading at the rate of 400 tons per hour.

gearing. The worm gears are enclosed in cast iron case to run on ball or roller bearings in oil-bath.

Conveyor belt tightening gears are the drop weight type for the long conveyors and screw adjustment for the shorter. Junction terminal shoots are provided with grids to break the fall of abrasive lump material; these grids are arranged for easy removal when handling materials that are likely to build up and choke the junction shoots. The feeder conveyors under the hopper receiving material from the crane grabs are of the pressed-steel apron type. The apron plates are of ¼-in. steel plating pressed to form overlapping knuckles bolted to chains at intervals of 4-in. pitch.

Chains are of two strands bushed and formed of malleable iron links fitted with removable hardened steel pins and bushes, each link being in the form of a 'K' type attachment for bolting to the apron plates. On the top carrying side the chains run on cast iron rollers mounted in sets of three at about 9-in. pitch. On the return side similar rollers are provided but not so closely spaced, and steel deck plating is provided between the strands. The drive from the motor is transmitted through worm and spur gear to the terminal shaft on which are mounted two cast-steel sprockets suitable for driving the steel bushed chain. Terminal bearings for these feeders are liberally designed with renewable brass bushes.

Foundation Work

The whole area occupied by the plant and the store was reclaimed ground filled in by material dredged from the sea bed to give the necessary depth of water for vessels moored at the quay face.

Special consideration had therefore to be given to the design of the foundation work to minimise any settlement that might be caused by the heavy live loads imposed on the crane and wing tripper rails. Careful tests were made on site and the foundations supporting the rail tracks were designed in reinforced concrete of very substantial size to ensure low unit pressures consistent with the carrying capacity of the soil. The deep excavation under the tippler hopper involved the use of pumps and other special equipment to drain the area adjacent to the excavation. The pit walls and approach gallery are of waterproof construction.

The mechanical contractor was responsible for the complete plant, including the foundation work, which was subcontracted to the civil engineering contractors who had built the quay.

Completion of Plant

The installation of the plant was completed in November, 1959, and the reception tests for its acceptance by the Portuguese Government were carried out by the end of the year.

Mobile Cranes for Ship Discharge

A Versatile Method of Cargo Handling

By JOHN ANDERSON, M.I.C.E., M.I.Struct.E., M.Inst.T.*

The need for improved turn-round of shipping at ports in Great Britain since the war has resulted in the development of various types of equipment for speedier discharge of vessels. Much has been accomplished in providing for specific kinds of traffic in which the problems to be dealt with are of a particular character and for which purpose-built equipment could be justified. Fork lift trucks, pneumatic hoists, power-driven elevators and conveyors, etc. have been successfully devised and developed to speed the handling of standard traffic peculiar to individual needs. These have revolutionised methods of goods handling and have provided a new approach to the problem of transfer of goods from ship to shore and their distribution to destination.

So far, however, little has been done in the pattern of crane production for general cargo handling, particularly at ports which cannot afford to maintain expensive portal crane equipment, so that the problem of speeding up the turn-round of ships has been aggravated by the lack of suitable intermediate types of crane to provide facilities beyond the standard available with ships' gear. Throughout the world, also, the development of cargo handling has taken different forms according to the circumstances prevailing at the different ports, e.g. the type of traffic, anchorage facilities, size of ships, whether carrying bulk or general cargoes, the labour supply available and the rates charged for services of equipment.

Much can be and has been said in favour of the different methods adopted and every method has its advantages in different circumstances but wherever ships' gear is not available, or is inadequate or unmanned, the use of quayside cranes of one kind or another is almost essential, particularly for heavy duties such as the discharge of bulk cargo or single lifts of containers, machinery, granite, etc.

Quay cranes are expensive and until recently there have been few suitable types of intermediate priced cranes for efficient discharge of, say, 10,000 ton vessels, other than those standard portal cranes which move on rail tracks laid on the quays. The less wealthy ports cannot afford to provide or maintain such facilities where there is not sufficient regular traffic to reasonably cover the costs involved. The larger ports usually maintain many batteries of quayside cranes, few of which are fully employed, and it is reasonable to suppose that for long periods of the year, probably less than 50% of the crane equipment is in daily operation. The total value of this unremunerative outlay must be considerable, and it should be as much a matter of concern to reduce the waste represented by the idle time of these costly units as it is to ensure the rapid turn-round of shipping. What is being done in the direction of securing maximum use of equipment?

Since the introduction of power driven appliances last century, traditional practice has dictated that cargo cranes be either fixed on quays at strategic positions, or confined to rails along which they could travel within the confines of the track laid down.

One of the most important developments of travelling equipment is the transition from rail-borne vehicles to road vehicles moving free on caterpillar tracks or on rubber tyres. So-called mobile cranes have been rapidly developed from relatively small capacity types and with the gradual increase of road-lorry weights designed for the transportation of heavier loads, it has been possible to introduce models of cranes capable of very substantial duties not hitherto considered feasible.

An interesting example of this type has been in use for the past three years at the Port of Aberdeen. This is a "Coles-Anderson" diesel/electric mobile tower crane, manufactured by Steels Engineering Products Ltd. of Sunderland.

As will be seen from the accompanying photograph this is a mobile crane specially designed for ship discharge work of a kind which hitherto could only be done by portal cranes on rail track. The crane has several novel features which have proved highly successful for the purposes intended and its general performance in practical use has been very high.

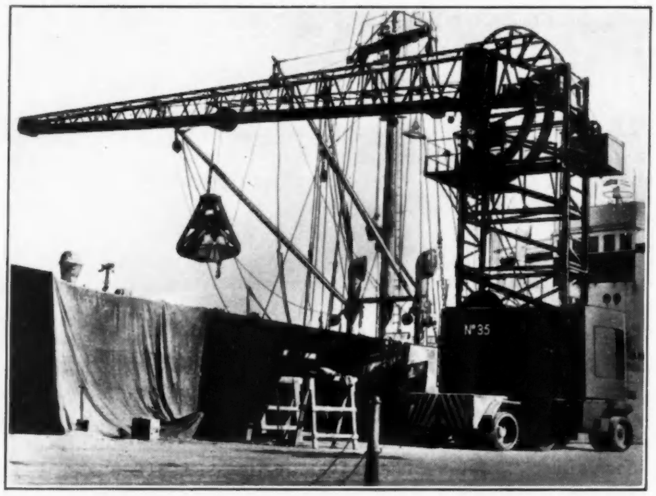
There are four of these cranes in use, two capable of carrying 1½ tons at 60-ft. and the other two handling 2 tons at 50-ft. so

*Mr. Anderson recently retired from the position of Chief Engineer, Aberdeen Harbour.

that on the different trunnion heights of 25-ft. and 30-ft. the maximum hook clearances are about 70-ft. and 85-ft. respectively. The cranes weigh approximately 53 tons each and travel at speeds of up to 5 m.p.h. They are designed to operate at all times free on wheels although one is provided with outriggers and a suitable lifting block, to permit of higher loadings than is possible when free. They are carried on 6 pairs of solid rubber-tyred wheels which are readily removable for repair or renewal of treads.

The crane travel is operated from the normal driving position, whilst all other motions for cargo discharge are controlled from the operating cabin immediately under the jib, i.e. about 25-ft. above ground level.

The rotating superstructure carries a 100 h.p. Perkins diesel engine as the prime mover for an electric generator of D.C. current, 50 kW. at 2,000 r.p.m. which is distributed to separate motors for the travel, hoist, slew and luff motions separately controlled from the craneman's cabin by contactors and servo-brakes. A special transporting arrangement has been included with the hoist transmission which permits of the load being moved inward and outward along the jib thereby eliminating the usual slewing and luffing motions required for bringing loads inshore. This simple arrangement is capable of high speed operation involving a straight path instead of the slewing curved path which is sometimes impossible in practice owing to rigging obstructions.



A mobile tower crane on grabbing duties at Aberdeen.

The slewing and derricking motions are actuated by rack and pinion transmissions, the jib motor being carried on the jib itself which is designed as a cantilever rotating vertically about a trunnion set at a level of 30-ft. above quay level.

The jib trunnion is supported on a tower which carries two derricking racks of 6-ft. 8½-in. radius, permitting the jib which is counter-balanced to fall to the horizontal position where it is held by a stop in the normal transporting position.

The transporting arrangement permits the hoist rope pulley to travel on a small supporting bogey up and down the jib, an operation which can be carried out with the jib at any elevation. Normally the transporter moves parallel to the jib so that its path would be horizontal when the jib is down but various angles of elevation are possible, and a horizontal load path can be maintained with the jib elevated. The transporter can thus be used to luff a load inwards without derricking and this is frequently an advantage for small movements in close riggings, obviating the use of the derrick motion.

The jib carries a light track suitable for the hoist bogey to travel along. The transporter rope passes over the head pulley normally occupied by the hoist rope which in this case is carried on the mobile bogey and the two ropes — hoist and transport — are arranged so that they leave their barrels in opposite directions paying out and taking in at equal speeds to give a load path parallel to the jib. This path can be varied by altering the ratio of hoist barrel speed to transport barrel speed which are linked together by suitable gearing.

Speed of operations is controlled through the engine accelerator pedal and desired motions are introduced whilst the engine is " ticking over " at slightly reduced speeds. Additional motions are introduced by merely temporarily releasing the accelerator pedal and switching in and re-accelerating.

The hoisting and transporting motions are driven by a common 60 h.p. motor with an electro-mechanical braking system. The hoisting speed is variable up to 2 tons at 250-ft. per min. Derricking is effected by means of a 12 h.p. electric motor driving worm reduction gear. Maximum to minimum radius is covered in 15 seconds. The superstructure can be slewed in a complete circle in either direction at a speed of 2 revs/min, driven by a 6 b.h.p. motor through a vertical worm reduction gear box. The superstructure is carried by a large diameter live ring of steel rollers, bolted to the chassis frame. The jib is provided with an audible safe-load indicator and also a visual indicator to show the position of the transporter bogey along the jib for safety in handling heavy unit loads.

Whilst these cranes are about as large as might be considered practicable, their efficiency is already established and there can be little doubt that such units may well be the answer to many problems peculiar to the average smaller type port capable of receiving vessels of the Liberty class, yet unable to provide the more costly equipment available in the larger undertakings.

The cranes introduced at Aberdeen have been designed to cater for bulk cargoes and they are adapted for self-dumping ring discharge or two-rope grabs. High operational speeds have been achieved with most commodities as the following figures show per crane: Coal up to 60 tons/hr; phosphates up to 60 tons/hr; lime up to 80 tons/hr; pyrites up to 50 tons/hr; timber 6 standards/hr; grain 27 tons/hr; coke up to 45 tons/hr; sulphate up to 45 tons/hr.

A special feature of these cranes lies in the simple transporting device. By means of a cantilever jib with its transporting facility it is possible to depart from the normal jib head loads by transporting the bogey inward to permit of 11-ton loads being handled at 15-ft. radius when a special need arises such as the handling of heavy lifts, e.g. granite blocks.

This adoption of a transporter motion coupled with normal crane practice has proved advantageous and results have shown that faster operation is possible than by normal derrick and slew operations. At all normal speeds the transporter method of handling goods has the distinct advantage of not requiring the use of slewing and derricking motions so that much heavy wear and tear of equipment can be avoided and the safety characteristics are superior to usual practice due to the straight path shorewards of the load and the short fall of ropes. When the crane is being used to slew with jib elevated the working radius may be quickly varied by moving the transporter bogey along the jib in preference to derricking inward of outward.

Owing to their versatility these Cole-Anderson cranes have proved highly useful. In terms of potential utilization, experience has shown that up to 80% of available working time may be exploited for general work, either by grabbing of bulk cargoes or operating on hook. This is a high figure judged by any standards, even where equipment is laid down for specific regular traffic only. This potential utilization is made possible by the transference of cranes over three or four quays in the course of a week, a facility which is not available to users of rail-tied cranes.

New Method of Dockside Timber Handling

Speeding Shipments by Mechanical Sorting

Automatic Length Sorting Machine

A new automatic handling and sorting machine for timber which can do the work of 60 men is now in operation at the Phoenix Timber Co. Ltd., of Rainham, Essex. It is claimed to be in advance of any similar machine operating anywhere else in the world, including the United States of America.

The new machine has been manufactured by B. & A. Engineering Co. Ltd. of 50 Pall Mall, London, after five years of development and research in association with the Phoenix organisation who decided it was necessary to devise a new procedure which would reduce the physical work of the dockers.

Softwood arrives alongside the quay in mixed lengths and before despatch to sites all over the country has to be sorted into batches of equal length and size. The machine which has now been produced is 240-ft. long x 130-ft. wide and in the design full use has been made of the latest techniques in electric, hydraulic and pneumatic controls. It will receive (dependent on size and average length of timber) more than 150 standards (equals 25,000 cu. ft.) of timber per day in mixed lengths and deliver at the other end packages of predetermined lengths steel banded for loading onto vehicles. In addition, the machine can "stick" the timber without in any way impeding its speed of operation. This is a process in which short thin lengths of wood are inserted crosswise between the lengths of timber in a batch to allow air to circulate around the individual pieces.

The Phoenix Timber Co. Ltd. have not yet had an opportunity of finalising the arrangements for feeding on and taking off the timber and therefore at this stage they are using standard cranes for both operations. Because of this they are not as yet getting the fullest advantage with regard to manpower. However, it has already been established that, including crane operators at both ends, a team of from 12 to 14 men is required to operate the machine, performing the work which, under normal conditions with usual mechanical aids, is now being done by a minimum of 60 men. Physical effort is almost completely eliminated.

Automatic Quality Sorting and Measuring Machine

It is usually the case with hardwoods that a parcel of timber contains pieces of many different widths and lengths. The sorting and measuring of these different sizes is an expensive and lengthy operation. B. & A. Engineering Co. Ltd. were also commissioned, therefore, to produce a conveyor assembly which would break up a rough bundle from a ship so that the pieces would pass individually over the conveyor and could be selected for size and quality in passage and made up into steel strapped batches with or without "sticks".

Soon after this machine was developed it became apparent that its output would be limited by the capacity of the measuring clerk who has traditionally to measure each piece of timber to $\pm\frac{1}{4}''$ in width and $\pm 3''$ in length (the superficial measurement) and write it in chalk on each length. Another clerk records it in a book and works out the total of each batch.

The quality sorting machine was capable of handling well over 3,000 cubic feet of timber per day whereas the usual performance of an efficient measuring clerk was between 800 and 1,000 cubic feet per day. Faced with this problem Phoenix commissioned New Electronic Products Ltd., a leading firm of specialists in the application of electronic instruments in industry, to solve it. It was required to produce a method of measuring the timber as custom demands but to speed up the process by using the latest electronic and computer techniques.

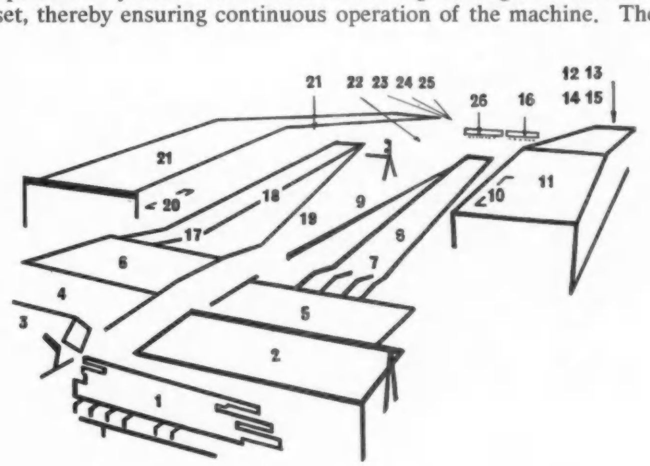
A machine has now been developed which measures the width and length of every individual piece of timber passing along the conveyor. The surface area is computed and carried in the electronic memory. Printing equipment attached to the machine records this information and presents the total surface measurement of a batch on demand.

The machine also includes a feature to measure softwoods where only the length measurement needs to be recorded. A counting mechanism accumulates the number of pieces of any one length together with the total of all the pieces in the batch, all figures being visible on a counter panel for manual or other reproduction. In due course this information will also be printable on demand.

Technical Description of the Length Sorting Machine Model LS A.I.

The main tilt hoist(1), foot-pedal operated, receives the rough sets of boards and discharges layer by layer to the main control conveyor(2). By intermittent stop/start this unit regulates the flow of boards to keep the machine working to full capacity.

The auxiliary tilt hoist(3) is identical to the main tilt hoist but operates only when the main unit is being recharged with a new set, thereby ensuring continuous operation of the machine. The



flow of boards from this hoist passes to the auxiliary control conveyor, which, by intermittent stop/start regulates the flow while the main tilt hoist is being recharged.

The transfer conveyor(5) automatically sorts the boards so that lengths less than 15-ft. will go forward to sorting conveyor A and longer boards to sorting conveyor B(6). When the main tilt hoist is working it conveys sideways to transfer conveyor B those boards of greater length than 15-ft.; alternatively, when tilt hoist B is working it receives from transfer conveyor B all boards of lesser length than 15-ft.

Transfer conveyor B automatically sorts the boards so that lengths greater than 15-ft. will go forward to sorting conveyor B. When the main tilt hoist is working it receives from transfer conveyor A those boards of greater length than 15-ft. and alternatively, when the auxiliary tilt hoist is working it conveys sideways to transfer to conveyor A those boards of less length than 15-ft. but still passes forward boards of greater length.

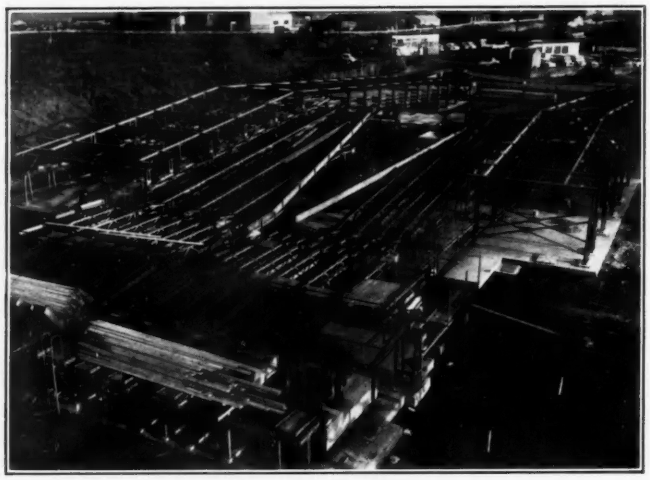
From this point onwards until the finished sets are removed to storage the machine is divided into two completely separate but identical sections, each consisting of the same number of items. One section of the machine deals with boards shorter than 15-ft. and the other with boards from 15-ft. to 24-ft. long. The following describes the section of the machine dealing with the shorter lengths of boards, 14-ft. and under.

The stop conveyor(7) receives the boards discharged from the transfer conveyor. It squares them across the table and controls the flow of boards to the length sorting conveyor,(8) so that regardless of width, only one board can lie between an adjacent

pair of vertical dogs of the length sorting conveyor. Having been fed with one board between an adjacent pair of dogs, the length sorting conveyor carries the boards forward until, depending on its length, one end of the board contacts the skid board(9) and thereby is caused to project out from the other boards so that it is caught by the appropriate power roll and transferred lengthwise off the conveyor to fall into trays. In this way, each tray receives boards of the same length only. Due to the skid board being at an angle to the sorting conveyor, it causes boards of each length to project at the appropriate take-off rolls and thereby to be transferred to the trays.

The take-off rolls(10) are power-driven and are approached from small inclined ramps up which the boards of corresponding length climb; immediately a board hits the take-off rolls it is conveyed sideways into the trays. By a special system of transfer it is possible for boards of the same length to follow one another on to the take-off rolls before the preceding board has cleared them, thereby greatly increasing the capacity of the machine and permitting a continuous flow of boards into the trays.

Each tray(11) consists of two rows of roller track down which the boards slide. Stops are arranged at the lower end of the tray so that the boards of one length can be collected until there are more than sufficient to complete a finished set. When it is



Timber Sorting Machine. General view from feeding end.

desired to make a finished set of a particular length, the stops of the appropriate tray are thrown into automatic control so as to release intermittently the correct number of boards to form a complete layer of the set, at the same time holding back the remaining boards in the tray. Boards released from the tray are carried forward to the set-making machinery by the gathering conveyor(12).

Setmaking

When set-making a particular length of board, the tray stops release the boards in accordance with a predetermined time cycle so that layer after layer falls on to the gathering conveyor and is transported to the set hoist(13). This is a vertically moving platform on which the layers of boards are deposited one on top of the other by layering fingers (14) until a complete set of one length of boards has been collected. The hoist platform lowers the appropriate amount immediately a new layer of boards has been deposited until the complete set has been built. The boards forming each layer can be arranged either close together or with a space between each board. The movement of the layerer fingers and the positioning of the set hoist suitable for receiving the next layer is completely automatic.

These fingers oscillate backwards and forwards in a horizontal direction carrying a complete layer of boards from the gathering conveyor and depositing it on the set hoist.

Where it is necessary to place sticks between certain layers of the set in order to stabilise it or to give air space for kilning, the appropriate number of sticks can be dropped without interrupting the action of the layerer fingers simply by the operator pulling a lever (15). Immediately a completed set has been gathered on the set hoist these power-driven rolls(16) transport it lengthwise to storage space awaiting removal by fork-lift truck or to the steel strapping section, if required.

The machine is limited to handling boards of $1\frac{1}{2}$-in. to 3-in. thickness and 4-in. to 9-in. in width.

Items 17-26 shown in the accompanying diagram are repetitions of items 1-16 described above.

Alternative Model L.S.H.

A simplified low-cost machine without the mechanical feed and setmaking machinery is also available. This is designed to receive hand-fed individual boards and to automatically sort the individual lengths into short trays from which boards would be removed and built up into a set by hand.

Boards of less than 10-ft. are discharged into a common tray, boards 10-ft. to 18-ft. are discharged into individual trays of 1-ft. difference in length, boards 19-ft. to 24-ft. are discharged into a common tray, making a total of 11 stations. To feed the machine, a crane or forklift truck would be used to place the sets on to the feed table from which the operator turns down individual boards by hand on to the conveyor.

Alternatively sets can be placed on bolsters on the ground and boards hand fed into a small elevating conveyor which raises them to the main sorting conveyor line.

Sorted boards are built into sets by hand on gravity roller tracks which facilitate withdrawal of a complete set to the side of the machine for removal by fork-lift truck or crane. The output of this machine is, therefore, governed by the rate of hand-feeding and the amount of labour concentrated on the manual set-making.

A simplified form of the Model LSA.1 length-sorting machine can be supplied having mechanised feed and set-making, but sorting to length at only eleven stations instead of seventeen. It differs from LSA.1 in so far as the feeding and set-making machinery are not duplicated and other design features have been incorporated which substantially reduce the initial cost without a proportional reduction in output.

Trade at the Port of Wellington

The annual report of the Wellington Harbour Board for the year ended September 30, 1959, states that the trade of the port showed a considerable decrease in cargo tonnage handled, the total of 2,302,159 tons being the lowest recorded since 1953, and a fall from 1958 of 290,779 tons. Imports totalled 1,444,317 tons, a decrease of 234,899 tons, or 14%. Exports of all classes totalled 673,850 tons, a fall of 40,766 tons or 5.7%.

The financial results also showed a decline and reflected the lower level of port trade. The Board's income was reduced by £58,699, while expenditure dropped by £47,925, the net result being a surplus on working account for the year of £9,327 compared with a surplus of £20,101 for the previous year.

During the year the harbour works programme was centred mainly on the reconstruction of the south inner tee Queen's Wharf, the contract for the new wharf structure, 404-ft. long and 120-ft. wide, being completed in August last. A contract for the erection of a cargo shed (No. 6) on the new tee is in hand.

Canadian National Harbours

Abstracts from the Annual Report for 1959

The 24th annual report of the National Harbours Board of Canada has now been published and covers the operations for the calendar year 1959 of the harbours of Halifax, Saint John, Chicoutimi, Quebec, Three Rivers, Montreal, Churchill and Vancouver, and the Government grain elevators at Prescott and Port Colbourne.

The number of vessels using the ports was 48,173, the aggregate net registered tonnage being 57,417,941, as compared with the figures for 1958 which were 48,242 vessels aggregating 47,894,829 net registered tons. Aggregate cargo tonnage in 1959 was 48,668,444 as compared with 47,083,690 in 1958, the increase being 1,584,754 tons or 3 per cent. Grain traffic showed a decline, however, from the previous year, dropping from 13,217,637 tons to 12,154,457, a decrease of 1,063,180 tons or approximately 8 per cent. Other commodities with aggregate tonnages in excess of 200,000, showed increases in fuel oil, crude petroleum, gasoline, pulp-wood, gypsum, motor vehicles and parts, sand and gravel, newsprint, asbestos, wood-pulp, iron or steel band, bars etc. and hog fuel. Decreases were shown in bituminous coal, lumber, wheat flour, raw sugar, logs and cement.

Foreign inward traffic increased 2,531,769 tons or 24 per cent, and foreign outward traffic decreased 297,109 tons, or 1.9 per cent, compared with 1958. Domestic traffic inward decreased 1,117,288 tons, or 8.9 per cent, and domestic traffic outward increased 467,783 tons, or 6.4 per cent, compared with 1958.

Operating income during the year amounted to $24,206,496 as compared with $24,075,931 in previous year, an increase of 130,565. Expenses of administration, operation and maintenance in 1959 were $15,598,321 as against $14,786,764 in the previous year, an increase of $811,557. The net operating income was $8,608,175 as against $9,289,167 in 1958, a decrease of $680,992.

After taking into account other income and deducting special charges, including interest on debt and reserve for replacement of capital assets, operations for 1959 resulted in loss of $594,847 as compared with a profit of $1,072,208 in 1958.

Construction Works

Major construction projects completed or in progress in 1959 included new or improved wharves at Chicoutimi, Quebec, Montreal and Vancouver; three new transit sheds at Quebec, Montreal and Vancouver and extensions to a transit shed at Montreal; addition and/or improvements to grain elevators, loading and unloading facilities and equipment at Halifax, Saint John, Quebec, Montreal, Prescott and Vancouver; installation of a blast freezer at Quebec, and refrigeration and ice manufacturing equipment at Vancouver; widening the roadway and improvements to the approaches, Jacques Cartier Bridge; construction of piers, superstructure, and placing of fill for Champlain Bridge. Uncompleted work at the end of the year on major contracts amounted to approximately $10,804,700.

Manufacturers' Announcements

Shipment of Liquids in Bulk

Early this year Marston Excelsior Ltd., a subsidiary company of I.C.I. Ltd., introduced 'Portolite' flexible tanks to provide lightweight containers for the transport and storage of a wide range of liquids. In collaboration with the Holland Steamship Company and British Amsterdam Maritime Agents Ltd., Hull, they carried out a trial shipment of liquid across the North Sea, and the tank, lashed to a hatch in the bows of the vessel, travelled well, even during a force 8 gale.

The 750-gallon tank on its pallet was secured in the bows on top of No. 1 hatch cover because, in this position, it would be subject to the maximum amount of motion; datum lines were marked on the tank, pallet and hatch cover, and checks for movement were made at regular intervals throughout the voyage. In spite of the vessel pitching 8 to 10-ft. at 8-second intervals and rolling 25 degrees every 6 seconds, the tank did not move during the entire voyage.

A cargo of 2,500 gallons of anthracene oil was also shipped recently in a 'Portolite' tank on board the 320-ton dwt. motorship "Fortuna" from Corporation Quay, Stockton to Copenhagen. It was the first of a regular series of shipments from Teesside to Copenhagen.

Due to widely differing requirements, the fabric of the tank is governed by its contents which can include petrols, mineral oils, vegetable oils, water, latex, chemical salt solutions, alcohols, detergents, molasses, alkaline solutions, ketones, esters, dilute acids and fruit juices. Generally, the tanks are made from coated strong woven fabrics, and filling and emptying connections to suit individual needs can be supplied; the corner of the container is the most suitable place for a connection.

When used on road or rail transport, the 'Portolite' containers may be strapped on to the flat surface of an open-sided vehicle, or placed within the walls of a vehicle with sides if these are strong enough to withstand the load of the tank contents. Surge can be reduced to a minimum by ensuring that little or no air is allowed to enter the container during filling. The tank is most stable when completely full but when only part filled it has to be suitably lashed. When used on shipboard, the containers are made smaller and secured to hatch coamings with wire lashings attached to a harness of strong webbing. The empty container is placed on the hatch, pumped full from a road tanker, and sealed at the special branch pipe filling connection. This same procedure is used when the container is carried by truck. If, however, it is necessary to load or unload a full tank,

(Above) A tank ready for despatch with 800 gallons on board.
(Below) Empty tank rolled up in stowed position on 5-ton lorry showing ample space available for other cargo.

specially designed pallets may be used for handling by a hoist unit.

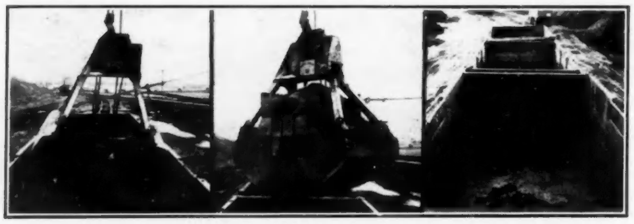
When empty, the tank can be rolled up into a small bundle and the full load space used for other cargo.

Active interest is being shown in the 'Portolite' containers by chemical exporters to whom the saving in cost of bulk delivery, especially of cheap commodities on which the cost of containers and handling weighs heavily, can mean the difference between competitive and uncompetitive selling prices abroad.

Self-Trimming Grab

A grab which completely obviates hand-trimming when used to unload wagons has been designed and is now being manufactured by Michael and Partners Ltd. of Chesterfield. First developed for use on the company's own civil engineering operations, this grab proved so successful that it was decided to manufacture it for sale with capacities of up to 3 cu. yds.

When the grab is fully open the jaws are vertically parallel and measure 7-ft. 11¼-in. across so that they can slide exactly down the 7-ft. 11½-in. inside width of a steel wagon. Although wooden trucks are a few inches narrower, the grab jaws remain outermost even when partly closed so that the same performance is achieved as with the steel wagons.



(Left) The grab slides exactly down the inside width of a standard steel wagon (centre) A full load is lifted every time. (right) The unloaded wagon has been completely trimmed without manual labour.

Owing to the receding radius of its jaws the grab digs into the stock throughout the closing stroke and lifts a full load every time. The jaws are geared together to give consistent, smooth closing, and are bevelled and hard faced and so are able to cut straight in to the stock under the grab's weight. They are made of mild steel and alloy steel link and trunnion pins are used in conjunction with hardened steel bushes. None of the pins protrude beyond the bucket faces and they are all fitted with recessed high pressure grease nipples. The hardened steel pulleys run on roller bearings and are very quickly released for reeving up or alteration of reeving, which is available in ratios of 2:1 4:1 or 5:1. The rope anchors are easily accessible and are of the wedge and socket type.

As well as handling coal and coke, these grabs have proved efficient in unloading iron ore, rock phosphates, limestone and other heavy bulk materials.

Flood Water Relief Scheme

The Cheshire River Board has awarded a contract, valued at £216,000, to John Howard and Company Ltd., civil engineering contractors, for a flood-water relief scheme. This work will involve the construction of a mass concrete and sheet pile cofferdam for the reclamation of a portion of the Morpeth Branch Dock at Birkenhead, on which will be constructed a pumping station, diversion channels and discharge tunnels under the existing dockside into the River Mersey.

The consulting engineers for this scheme are Messrs. Sandford, Fawcett and Partners, and the contract time for completion is thirty months.

New Transit Shed for Port of London

The new Transit Shed at No. 4 Berth, Royal Victoria Dock, London, described elsewhere in this issue is the largest so far built by the Port of London Authority.

Enclosing an area of nearly 4 acres, it is 700-ft. long 200-ft. wide, 66-ft. high at the ridges and 23-ft. high at the eaves. There are covered loading bays at each end.

The structure is mainly in tubular steel and an interesting feature is that it embodies in its construction nearly 100 tons of aluminium. The entire roof and sides are covered with 18 S.W.G. Rigidal Industrial supplied by The British Aluminium Company Limited.

Aluminium cladding combines durability, strength, lightness, thermal insulation and an absence of fire hazards. It is particularly suitable for buildings exposed to a marine atmosphere because it needs little or no maintenance. Rigidal Industrial Trough 6T profile was used for the roof-covering and a modified Rigidal Industrial Trough LT7 profile for the walls. The longest length of sheet supplied was 21-ft. 10-in. but the maximum length normally available is 35-ft. The availability of such lengths is an important advantage—long Rigidal sheets are still light enough to be handled easily on site, the number of separate pieces and joints in a given area is reduced and appearance of the finished job improved. The main fastenings for the sheets were N6 aluminium alloy "U" bolts and side laps were fastened with Imex rivets.